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THE EFFECTS OF COMMONALITY ON PAIRED-ASSOCIATE LEARNING IN TWO AGE GROUPS*

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A. INTRODUCTION

In attempting to account for the decline in performance with age in a variety of learning tasks, there has been considerable use made of the concept of interference. The assumption has been made that the older person has a host of pre-existing habits which may hamper the acquisition of new skills. This type of explanation is particularly appealing when the studies involve verbal learning, since the task usually involves the modification of stable language habits with which the person enters the experimental situation. However, the data supporting an interference hypothesis have been equivocal. The classic study by Ruch (7) indicated that the modification of older well-established habits (i.e., nonsense equations) was more difficult for the older person than the younger person. A partial replication of his study by Korchin and Basowitz (6) failed to confirm these earlier findings. Gladis and Braun (3) also did a positive transfer study which is often cited as supportive of interference theory. These authors pointed out that since the older subjects exhibited less positive transfer than did the younger subjects, the study can be regarded only as providing indirect support. A more straightforward test than this of the interference hypothesis demands a specification of the linguistic habits with which subjects enter the experimental situation. To obtain indices of verbal style, the author resorted to the classic word-association technique. Jenkins (5) and his colleagues have investigated the characteristics of individuals who respond with a high or a low percentage of common responses to the stimulus words of the Kent-Rosanoff list. One of the intriguing findings was that high-commonality subjects show a consistency of responding over a number of different occasions. In contrast, the low-commonality subjects are inconsistent from one occasion to another. They give different, but uncommon responses, on each occasion. A paired-associate study utilizing high- and low-commonality subjects indicated that high-commonality subjects learn high-strength associate

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pairs more readily than low-commonality subjects and low-commonality subjects learn low-strength associate pairs more readily than do the high subjects. The study suggested that high-commonality subjects show large and predictable facilitation through associative habits and that low-commonality subjects exhibit a somewhat greater ability than the former to form new habit patterns. If established modes of responding are more interfering for the elderly than for the young, the aged high-commonality subject should have differentially greater difficulty than the young high-commonality subject in acquiring new responses. Conversely, the elderly low-commonality subject, with his presumably less stable language patterns, should not exhibit the same degree of disability.

B. METHOD

1. *Subjects*

The experimental groups were composed of 60 elderly and 60 young subjects. The groups had mean ages of 65.73 and 16.77 years, respectively. The elderly subjects were drawn from a domiciliary population. An attempt was made to sample from the more highly educated sample of this population and only those persons who had some high-school education were used. The young subjects were drawn from a population of high-school students who were doing volunteer work during the summer months.

2. *Apparatus and Procedure*

The vocabulary subtest of the Wechsler Adult Intelligence Scale (9) was administered to all subjects, in order to determine if there were significant differences in intelligence between the groups. (The elderly subjects had a mean raw score of 55.57 while the young subjects had a mean raw score of 61.35.) In addition, all subjects were given the Kent-Rosanoff Word Association Test and a commonality-score index was obtained by utilizing the 33-item commonality scale developed by Horten, Marlow, and Crowne (4). This test utilizes 33 stimulus words from the Kent-Rosanoff list which elicited responses that were given by at least 50 per cent of a normative group. These 33 primary responses were also primaries on the Minnesota Word Association norms (8) and our own norms (2). The correlations between full-scale commonality scores and commonality scores based on the 33 primary responses ranged from .95 to .98 in the Horten study, indicating that commonality scores based on the 33 primary responses adequately reflect the word-association patterns. Only extreme scorers in either direction were utilized in the present study. The 30 high-and-low-commonality scorers in each age

group were then randomly assigned to groups of 15 subjects which learned paired-associate lists of high or low associative strength. This grouping with the mean commonality scores is presented in Table 1.

The response members of the high-commonality paired-associate list were composed of the most frequent responses to the 10 stimulus words used in the list as obtained from the Russell and Jenkins norms. The response members of the low commonality paired-associate list were composed of responses to the same 10 stimulus words which were elicited only once in the one thousand times.

TABLE 1
MEAN COMMONALITY SCORES FOR THE EXPERIMENTAL GROUPS

Group	High assoc. list	Low assoc. list
Young		
High-commonality score	25.27	22.60
Low-commonality score	9.73	8.87
Old		
High-commonality score	24.40	23.00
Low-commonality score	6.07	7.35

The paired-associate material was presented on three-by-five cards with block lettering one-and-one-half inches high. All learning took place under self-paced conditions in order not to place the elderly subjects at a disadvantage (1). The material was learned to a criterion of one correct recitation.

C. RESULTS

Because the WAIS vocabulary subtest indicated that there were slight differences between groups as regards intelligence, a $2 \times 2 \times 2$ analysis of covariance was utilized and is presented in Table 2.

TABLE 2
RESULTS OF ANALYSIS OF COVARIANCE

Source	df	ss	ms	f	p
Age	1	3,449.74	3,449.74	14.66	.001
Commonality	1	670.31	670.31	2.84	n.s.
List	1	12,350.60	12,350.60	52.65	.001
Age by Commonality	1	394.00	394.00	1.67	n.s.
Commonality by List	1	1,290.96	1,290.96	5.49	.025
Age by List	1	2,454.10	2,454.10	10.43	.005
Age by Commonality by List	1	461.74	461.74	1.96	n.s.
Error	111	26,130.78	235.32		
Total	118	47,232.23			

The analysis indicates that there are significant age differences and list differences as regards error scores. Further, that there are significant age-by-list and commonality-scores-by-list interactions. However, there is no significant age-by-commonality-scores interaction and the triple-order interaction is also nonsignificant.

D. DISCUSSION

Certain aspects of the data analysis are not surprising. The large age differences in performance and the differentially poorer performance by the elderly persons on the more difficult list as evidenced by the age-by-list interaction were to be expected.

However, the important aspect of the findings is related to the nonsignificant age-by-commonality-score interaction and the nonsignificant triple-order interaction. It was hypothesized that if interference was an important factor in the learning disability of elderly subjects, a high-commonality elderly subject should exhibit increased associative strength with age and be more handicapped in learning a new set of responses. The low-commonality elderly subject should not have this disability. The previously mentioned nonsignificant interaction indicates that both groups of subjects experience the same relative degree of interference or facilitation. This interpretation of the data is strengthened, since there can be no question that the linguistic patterns of the subjects were operative and affected performance because the commonality-score-by-list interaction was significant.

While no single study can be expected to be conclusive as regards any theoretical construct, it should be emphasized that when the linguistic characteristics of elderly subjects were used as an independent variable, the hypothesis that the older person is more susceptible than the young person to the effects of interference was not supported.

E. SUMMARY

This study was designed to examine the hypothesis that elderly subjects are more susceptible to the interfering effects of pre-existing verbal habits than are young subjects. To obtain indices of verbal style, the Kent-Rosanoff Word Association test was used. Subjects were classified according to the number of common responses (high-commonality subjects) or the number of unique responses (low-commonality subjects) that were elicited. Previous studies on verbal learning suggested that high-commonality subjects show facilitation through associative habits and that low-commonality subjects exhibit a some-

what greater ability than the former to form new habit patterns. It was hypothesized that if established modes of responding are more interfering for the elderly, the aged high-commonality subject should have differentially greater difficulty than the young high-commonality subject. Conversely the elderly low-commonality subject, with his less stable language patterns, should not exhibit the same degree of disability.

In all, 120 subjects (60 elderly and 60 young subjects) were run in a verbal learning task consisting of high-strength and low-strength associate pairs. A $2 \times 2 \times 2$ analysis of covariance indicated that while the linguistic habits of the subjects affected performance, young and elderly subjects experienced the same relative degree of interference or facilitation in learning the lists. The hypothesis of increased interference stemming from pre-existing habits was not supported.

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BEHAVIOR THERAPY AND GERIATRICS*

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A. INTRODUCTION

In recent years behavior therapy has shown much promise in the treatment of psychotic (1, 3, 4, 8, 14) and neurotic behavior (17, 24). Behavior therapy has been effectively employed in the modification of deficit behavior, such as mental retardation (5) and some forms of delinquency (19). It has also been applied with some success to the treatment of disturbed children (9, 16).

A search of the literature reveals a dearth of investigation and speculation concerning the application of behavior therapy to the institutionalized geriatric patient. The only available speculation on this topic is a paper by Lindsley (18) on geriatric behavioral prosthetics. In this paper Lindsley makes a plea for the design of a specialized environment to restore competent performance lost due to reduced sensory capability.

It is the purpose of this paper to explore the possible use of behavior therapy in the treatment of geriatric patients in an institutional setting. Before this relationship is explored, it will be useful to present a brief review of the methods and implications of behavior therapy to provide a background for discussion.

Freud's emphasis on the unconscious (11) and the medical profession's influence on the understanding of abnormal behavior have led to the development of a medical model for the understanding and analysis of abnormal behavior. According to this model, the observed abnormal behavior is symptomatic of some underlying causal factors. In other words, the observed maladaptive behavior is not considered the important behavior for manipulation. Under this model, fear of high places would be interpreted as a cover-up or defense of a more basic underlying fear—i.e., fear of castration or fear of failure. The therapeutic implications of this model are far-reaching. Therapy, according to this model, should consist of the removal of the basic underlying unconscious conflicts. This involves much exploration and time.

There is also a very interesting therapeutic implication concerning the care

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of institutionalized individuals with abnormal behavior. Under the medical model, ward personnel, such as attendants, nurses, and volunteers, play a very minor role in the alleviation and remission of the maladaptive behavior. In this model, the ward personnel act, more or less, as custodians, until "real" therapy can be administered by the psychologist or psychiatrist in an individual or group situation. Of course, another "real" kind of therapy is the use of drugs, electric shock, and other such physical treatment. This point involving ward personnel will be discussed later in reference to care of the aged.

In recent years a new model has been developed concerning the formation and elimination of abnormal behavior. This new model is based on learning theory. It assumes that all abnormal behavior, unless there is known organic pathology, is considered due to faulty learning. Therefore, according to this point of view, principles developed from the laboratories of learning and experimental psychology should be used to derive therapeutic procedures for the treatment of abnormal or maladaptive behavior. Therapy based on learning theory is called Behavior Therapy.

B. TWO KINDS OF BEHAVIOR THERAPY

Two kinds of behavior therapy have been developed. One kind is therapy based on reciprocal inhibition (24). The other kind is based on operant-conditioning procedures developed by B. F. Skinner (10, 20, 21). This paper will discuss the methods of both reciprocal-inhibition and operant-conditioning therapy.

1. *Reciprocal Inhibition*

The main point of reciprocal-inhibition therapy is that anxiety is the central component of maladaptive or neurotic behavior. This approach has been used mainly with neurotic patients. Reciprocal-inhibition therapy aims to inhibit anxiety responses to objectively neutral stimuli by substituting a nonanxious response for the anxious behavior. Another way of saying this is that we try to develop parasympathetic responses which will inhibit the sympathetic nervous system or anxiety responses. Three widely used methods of reciprocal inhibition will be discussed.

a. *Desensitization.* Probably the most widely used is the method of desensitization. In this procedure, the patient is taught to relax by using Jacobson's (15) method of relaxation or some other method (I have developed my own) which insures that the subject can report feeling completely relaxed with no tension whatsoever. This training in relaxation usually takes from three to five sessions, and patients practice relaxation at home at least twice a day.

When the patient is able to relax thoroughly in the therapist's office, he is presented in imagination the fearful stimuli in such a manner that the least fearful aspects of this stimulus situation are presented first. This is done by a careful inquiry as to the things about the fear that bother him most or least. A hierarchy is thus constructed concerning his fear responses to the stimulus situation. Let us take, for example, the phobia of dogs. A hierarchy is constructed concerning this phobia. Maybe the patient fears most a dog sitting in his lap. Maybe his least fear over the dog is seeing the dog two miles away in a cage. The patient is told to close his eyes and relax, then instructed in the following manner: "I'm going to present a scene to you and when you are able to imagine it as vividly as you can without any tension whatsoever, please signal by raising your right forefinger." The least noxious item is thus presented first. The patient is then told: "I want you to imagine that you're at one end of a long street. At the other end you can just make out the shape of a dog in a cage. When you can visualize this and feel completely relaxed, raise your forefinger." When the patient responds by raising his forefinger, the next item higher on the hierarchy is presented. In this case it might be imagining the dog halfway down the street. This procedure is continued, bringing the dog closer and closer to him in imagination, until he can imagine playing with and fondling the dog while feeling completely relaxed. It is evident from the above description that the aim of this procedure is to replace the feeling of anxiety toward a noxious stimulus with a feeling of calm and relaxation. The very important point of this procedure has to do with the fact that there is usually direct transference from a feeling of calm in the imagined situation to a feeling of calmness and relaxation in the real situation.

b. Training in assertive behavior. The second procedure often used is training in assertive behavior. There are some very anxious patients who seem pulled and pushed and manipulated by individuals around them. They are often quite passive and silent when they should assert themselves regarding injustices done to them. They are told that they have to learn to speak up when they feel people are taking advantage of them and when they feel there is an injustice being done. Behavior rehearsals are conducted in the office, teaching the patient how to be assertive. Being assertive reciprocally inhibits (reduces) anxiety, and of course there is the secondary reward of getting one's way. After anxious subjects are able to assert themselves, there is a noticeable reduction in the overall anxiety level.

c. Aversion therapy. A third kind of procedure is aversion therapy. This

kind of therapy is often used in cases of obsessions and compulsions. Using aversion therapy, behavior therapists have been able to achieve very promising results in the treatment of homosexuality (12, 22, 23). In these cases, the subject is presented with pictures of male nudes (if he is a male homosexual). These pictures are often on slides and are flashed on the screen. As soon as the pictures are delivered, the subject receives an uncomfortable shock. After a number of these sessions, the subject begins to report that male homosexuals are not attractive to him. In fact, they even disgust him. At the same time he is encouraged to approach and date females. Often he has to be given assertive training in this respect. The results so far have been very encouraging. Thorpe *et al.* (23) have achieved a remission in six out of eight homosexuals using a similar procedure. By remission I mean they did not engage in any homosexual behavior and now engage exclusively in heterosexual behavior, often to the degree of being engaged and getting married.

The author has developed another kind of aversion therapy called Covert Sensitization (7) for the treatment of compulsive behavior. Thus far the treatment has been applied only to obsessive eating and alcoholism. In the case of an alcoholic, the subject is relaxed and instructed in the following manner: "I want you to imagine that you're walking into a barroom and you ask for a glass of beer. As soon as you ask for the beer, you start to have a peculiar nauseous feeling in your stomach and then you can sense your stomach being very upset. In fact, you feel like vomiting. As the bartender hands you the beer and you're about to reach for it, you feel like vomiting. The vomit comes up to your throat. You can't control it. You vomit all over the beer and all over the bartender. It's a disgusting mess."

This procedure is repeated nine or 10 times in each therapy session. Often the scenes are changed according to what and where the subject drinks. He is instructed to repeat the procedure himself at least once a day. So far, the results have been very promising. There has also been success with a case of obesity using this procedure.

2. Operant Conditioning

The other widely used behavior-therapy approach is based on operant-conditioning procedures. This approach has had much success with modifying behavior of institutionalized individuals, such as psychotics and the mentally deficient. The operant-conditioning model assumes that most learned behavior develops out of differential reward and punishment of activity of the individual. If the experimenter wants a response to increase in frequency, he follows

this response with a reinforcing stimulus—e.g., a stimulus such as food or praise. In this manner, he can gradually shape the desired behavior. If the behavior desired is sitting on a chair rather than lying on a floor (as is true of some regressed schizophrenics), whenever the individual lying on the floor makes any movement at all toward rising from the floor, he is given immediate reinforcement. This could be either an affectionate pat, a piece of gum, food, anything found to modify the individual's behavior so that this behavior can be repeated at a high rate. There are some general reinforcers that you can be sure will be reinforcing to most people—for instance, praise, money—but often we have to explore the individual's history and current behavior to find the most effective reinforcing stimulus for that individual.

C. APPLICATION TO GERIATRICS

Now what are some of the implications of the statements made concerning behavior therapy for the treatment and care of the aged in an institutional setting?

Since behavior therapy does not operate under the medical model, observed faulty behavior is the important behavior to be modified. It is not important to seek underlying causes for this behavior. It is not important to have the patient achieve insight (6). The faulty behavior can be modified by any individual's interacting with the individual exhibiting the faulty behavior.

In the behavior-therapy model, ward personnel, such as attendants, nurses, and even cooks, are important in the therapeutic process. As a matter of fact, one could argue that they are the most important agents in the therapeutic process; since these individuals interact with the patient more than anyone else, they have more occasions to modify the patient's behavior by reward or punishment (and in fact do).

This point of view has been implemented in a number of studies dealing with psychotic populations (1, 2). The nurses and attendants are taught behavior-therapy principles and are then told how to apply them in modifying the behavior of patients. The behavior considered desirable by the staff is to be rewarded by effective reinforcers. One of the most effective reinforcers seems to be of a social nature. Just paying attention, smiling, and talking to the patients often act as powerful reinforcers. Under these procedures, punishment, as such, is usually not used; rather the personnel are carefully instructed not to reward undesirable behavior. We are all familiar with situations where patients exhibit very interesting symptoms, such as standing against the wall, waving their hands, and mumbling. We often pay attention to such behavior

by pointing it out to other people, such as psychology students, volunteers, or even psychologists and psychiatrists. In other words, many times undesirable behavior is maintained because it receives a lot of attention.

We might look at some examples of how behavior therapy, especially operant conditioning, can be applied to the behavior of the aged in the hospital setup. One of the most frequent behaviors exhibited by the aged is simply not behaving, not doing anything, such as staying in bed, sitting, inactivity. Many times this is reinforced by the ward personnel because in many ways it is less work for them if patients are just immobile all the time. Activity means more noise in the ward, more questions that have to be answered, and more things that have to be done by the ward personnel. Many times, the ward personnel unwittingly discourage activity by ignoring questions asked or by placing the patient in a very comfortable position and then forgetting about him. With the behavior-therapy approach one could systematically reinforce behavior, such as getting up, walking, and talking, so that this behavior becomes a frequent mode of behavior of the patient.

Faulty eating habits have been very amenable to behavior-therapy modification (3). This is often done by nonrewarding or mild punishment of the faulty eating behavior. For example, if the staff has to feed the patient, they sometimes drop the food on the clothes, face, or neck of the patient. When clean or desirable eating behavior occurs, they are praised or given some other kind of reinforcement. If a patient is always staying in his room and will not come out to interact with the other patients, any behavior that leads to going out of the room is systematically reinforced, until he is interacting with the other patients in the dining room or recreation hall.

Although, for the most part, reciprocal-inhibition therapy has not been employed with institutionalized psychotics or in deficit behavior, there are one or two studies (8) which indicate that reciprocal-inhibition procedures can be effective with institutionalized psychotics. Also reciprocal-inhibition procedures can be used to supplement operant-conditioning procedures for the treatment of deficit behaviors—such as some forms of delinquency—mental retardation, brain-damaged organisms, and aged individuals exhibiting pathological behavior. Individuals with organic deficit are often further debilitated (13) by the resulting anxiety in attempting to adjust to the environment.

Reciprocal-inhibition therapy can also be used in the training of ward personnel. Often there are some nurses or attendants who feel uneasy with certain kinds of patients—e.g., the ugly or messy patient. Photographs of all types of patients could be taken and then a hierarchy built up for each nurse

or other ward personnel. Systematic desensitization is then employed so that all ward personnel feel at ease with every type of patient.

The following procedure is recommended for the application of behavior therapy on a geriatric ward: (a) Training is given to ward personnel in principles of behavior therapy with emphasis on operant-conditioning methods. (b) A discussion of each patient to determine the particular reinforcements for that individual is a crucial procedure. (c) A careful determination of the extent of organic pathology for each patient is necessary to provide a guideline for the appropriate behavior to be modified. (d) Desirable and undesirable patient behaviors are made explicit to all those interacting with the patients to provide consistency in treatment. (e) There should be demonstrations of behavioral training techniques by trained behavior therapists. The demonstrations should include actual attempts at modification of the patient's behavior. (f) Staff meetings held weekly to exchange information and discuss methods to be used will provide the necessary feedback for ongoing evaluation of the program. (g) Individual patients who seem resistive to the treatment are taken over by the trained therapist for individual attention. This is especially so where reciprocal-inhibition therapy is to be employed. (h) It is important to provide behavior checklists to be filled out for each patient before, during, and subsequent to treatment.

Though the application of behavior therapy to geriatric patients appears quite promising, controlled studies are needed in this area. Perhaps some of the generalizations derived from work with the mentally retarded and the psychotic population are not transferable to the aged organism functioning in a maladaptive manner. The quality, intensity, and scheduling of the reinforcing stimuli employed may differ with the geriatric patient. The reduced sensory input due to the aging process and the slower condition rate of the geriatric patient (18) may require a different functional relationship between different characteristics of the reinforcing stimuli and the behavior to be modified. Of course, one cannot be sure how much the slower conditioning rate is due to the reduced sensory input. Nevertheless, the variables in the geriatric therapeutic situation have to be investigated in their own right. Empirical investigation might reveal different lawful relationships between the reinforcing stimuli and the behavior of the psychotic, mentally deficient, and geriatric populations.

D. SUMMARY

In recent years behavior therapy has shown much promise in the treatment of varied behavior disorders. There is a dearth of speculation and investigation

concerning the application of behavior therapy to geriatrics. The assumptions and methods of behavior therapy are discussed for both reciprocal-inhibition and operant-conditioning therapies. Possible applications of behavior therapy to geriatrics in terms of individual treatment and ward management are presented.

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THE BODY-IMAGE IDENTIFICATION TEST: A QUANTITATIVE PROJECTIVE TECHNIQUE TO STUDY AN ASPECT OF BODY IMAGE*¹

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A. INTRODUCTION

Various aspects of body image (or "schema") have been studied by various investigators through different techniques and with different tools. What body image is has also been interpreted in many ways. Most investigators of these phenomena agree that body image is developed and modified by experience, sensations, and perceptions in living and is different for each person. It is the person's concept of his own body, it grows out of his personality, and it affects his behavior in terms of his relating to others. It is a psychological subjective experience.

B. BODY IMAGE AND PERSONALITY

Many aspects of body image have been investigated. Fisher and Cleveland's study (3, p. 207) deals with how the individual's concept of his body influences his behavior. "Persons differ considerably in the degree to which they conceive of their body *boundaries as definite and firm as contrasted to weak and indefinite.*"

Body image is related to psychosomatic symptoms, level of aspiration, tolerance of stress, and the ability to relate well to others on a personal level and it helps clarify these. Boundary-firm people rather than boundary-weak people are more people oriented, more spontaneous in expressing feeling, make more intimate contacts, and interact better with their friends and families. These people have high barrier scores on the Rorschach: i.e., Turtle-in-the-Shell and Knight-in-Armor responses. Fisher and Cleveland (3) also tested the hypothesis that high-barrier and definite-boundary people are more expressive sexually and found chi square to be significant in that direction: "The more definite

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¹ This study was taken from an M.A. thesis carried out under the direction of the second author, Department of Psychology, The George Washington University. Mrs. Edythe Polsby was the consulting artist.

an individual's body image boundaries, the greater his freedom to enter into intimate relationships and have expressive feelings" (3, p. 210).

Another study dealing with "Children's conception of body size," by Katcher and Levin (8), showed that older girls tended to identify with smaller body parts, perhaps having learned to identify with definite sex-role characteristics in which smallness is associated with femininity.

Hunt and Weber (7) investigated the dimension of body image primarily oriented to visual perception of height and proportions of the body.

Many studies of body image use the drawing of a person's figure as a projection of the structure of the personality and its distortions. Machover (9) was one of the first to analyze a person's drawing for personality traits, narcissism, aggressiveness, sexuality, etc. The subject is asked to draw a person and in doing so projects (it is thought) a body image or psychological photograph of himself. Some aspects of the personality characteristics allegedly demonstrated are lack of body confidence, lack of sex identification, dependence, and low self-esteem.

Haworth and Normington (6) constructed a sexual-differentiation scale for the Draw-a-Person Test. This scale had four categories of figures: (a) no apparent sex, (b) minimal differentiation, (c) one figure more differentiated than others, and (d) each figure well differentiated. Figures were objectively scored by a point system. This study showed that ability to differentiate between the sexes improves as a function of age rather than as a function of intelligence, but the question remains as to whether the scale is an index of sexual awareness only or is also an index of drawing ability.

Modell (10) studied changes in human-figure drawings by patients, who had recovered from regressed states, and found personality changes. When regression occurred, it was accompanied by a loss of sex differentiation in the body image, which returned with recovery.

Fisher and Fisher (4), in their study of disturbed women at a state hospital, found a significant relationship between the degree of femininity of figure drawings and the style of one's past sexual behavior. The cases of marked femininity or little femininity tended to have been the most maladjusted in their sexual relationships.

Brown and Goitein (1) tend to deal with the question of skill in drawing figures by blindfolding their subjects. Tait and Ascher (11) asked their subjects to draw the inside of the body. Witkin *et al.* (12) tried to determine sex differences in perception when the body itself is the object of perception. The emphasis was on bodily experience, and the experiences of women were

not significantly different from those of men when the situation permitted perceptual separation of the body from the visual field.

Hammer (5), using figure drawings to investigate body image, finds that most people draw their own sex first and that deviations occur among homosexuals and others with confusion of sex identification; that is, dependence on or undue attachment to the parent or member of the opposite sex and regression to the point at which one is "one with Mother." This is true even for those subjects who ask which sex they should draw first.

A body-image study was conducted by Deno (2) on adolescent boys whose body images, it was thought, were shaped by the idea of the importance of good physique. Each of 40 subjects was presented with a photograph of himself (a nude rear view). The ages ranged from 14:2 to 16:7, and *IQ*s ranged from 60 to 135. Each was asked to recognize himself and others. These subjects were familiar with each other. In spite of body preoccupation and mirror familiarity, only 37.5 per cent identified themselves correctly. Those who identified themselves were also better at identifying others than those who did not identify themselves. Certain physical characteristics may have set this group apart and made them more aware of physique. High status for masculine characteristics were broad shoulders; a V-shape torso; muscles; a strong back, arms, and legs. Actual body physique was not the same as body image, and mental age and *IQ* played no part.

The present study was devised as a quantitative test to measure feelings of masculinity-femininity as they relate to body image.

C. SUBJECTS

The subjects consisted of three major groups differentiated and classified by the terms "normal," "disturbed," and "slow learners." The group of slow learners was further divided into two subgroups.

The slow learners consisted of 21 females and 21 males (ages ranging from 13 to 17), who attended a public junior-high school in the District of Columbia, needed and received a remedial-reading program, and were in Grades 7 through 9. *IQ* scores for most of the students were under 85, but these scores were not completely dependable (having been secured from a variety of tests, some as far back as three to five years). Further, this group was for the most part culturally and economically deprived. Subjects for testing were selected randomly by the teachers on the basis of availability.²

² The test on which this study is based was administered during the months of May and June, 1962.

The disturbed group of 30 males was subdivided into two groups, but was treated as one sample statistically. All were males (ages 8 to 11) who were considered unable to function in a regular-classroom or school situation. Most of them lived and attended school in a residential-treatment center because of disturbed family relations. *IQs* ranged from 85 to over 200 on either the Stanford-Binet or the Wechsler Intelligence Scale for Children. A few lived at home and attended school in the center. Fourteen boys were at Hillcrest Children's Center, Washington, D. C., attending the school and receiving treatment. Five of these boys also lived at the Center. All subjects were in therapy. Sixteen boys lived and went to school at the Episcopal Home for Children, Washington, D. C. Not all of these children received therapy, but it was available to both parents and children if the staff felt it would be useful. The Episcopal Home school program was more structured than the Hillcrest program. Classrooms might hold only one child, but were set up physically like a normal school classroom. A child could be excluded from school, and it was the responsibility of the child to get himself accepted back into the classroom. If a child wanted to terminate his stay at the home, he made his own appointment with the director to discuss the matter.

Both Hillcrest and Episcopal subjects were largely school-exclusion cases who could not live at home. Reasons included excessive acting out, stealing, running away, character disorders, nonlearning, withdrawal, as well as impulse-ridden, neurotic, hostile, hypersensitive, behavior, with inability to handle frustration in general. Possibly a few were organically brain damaged.

The third major group consisted of 31 males (ages ranging from 8 to 11) in Grades 2 to 6 in the Town and Country Day School, Wheaton, Maryland, for normal children. *IQs* were normal or higher. These boys were considered, for purposes of this study, a normal control group simply because they were able to function in a normal school situation and had manageable relations with their families. All the boys present on the day of testing were included in the study, and there was no other basis for selection.

D. APPARATUS

A quantitative measure consisting of a series of seven body drawings was devised. The apparatus consisted of seven pictures (drawings) of the human body, each differing from the next quantitatively in seven dimensions, on a continuum according to an exact scale. Body image, being a subjective experience, was related to feelings of masculinity and femininity. The artist tried to incorporate some of the essential differentiating qualities between

masculine and feminine attributes although no genital organs were shown. The figures were without clothing and were in outline form. It was hoped that masculine and feminine differentiation would be achieved through changed dimensions in (*a*) the curve of the eyebrow, (*b*) the direction in which the eyes are looking, (*c*) the amount of eyelash, (*d*) the shape and fullness of the lips, (*e*) the width of the shoulders, (*f*) the size of the waist, and (*g*) the size of the hips. Size of the arms, legs, neck, hair, head, and height of figures remained the same throughout the series.

There were anterior views of seven whole figures, seven face parts, seven shoulder and arm parts, and seven hip and leg parts. The whole figures were six inches high and were centrally placed on four-inch by seven-inch white cards. The figures were drawn according to what is considered normal proportions, the body length measuring seven times the head length.

The scale, varying in exact amounts from one to seven assumed that the figures ranged from most masculine—1—to most feminine—7—as (*a*) the eyebrows became more curved, (*b*) the eyelashes became fuller, (*c*) the lips became fuller, (*d*) the eyes changed from a direct, straight frontal glance to a sidelong glance, (*e*) the shoulders decreased in size by equal amounts from one to seven, (*f*) the waist decreased in size from one to seven, and (*g*) the hips increased in equal amounts from one to seven.

Each figure was divided into three parts: namely, head and neck, arms and chest, and hips and legs. The separate parts—seven faces, seven shoulders, and seven hips—were placed on 21 four-inch by seven-inch cards in the respective positions in which they originally occurred in the whole-figure cards, the rest of the card remaining blank. (See Figures 1 to 4.)

In Figure 1 are shown the seven bodies in which the shoulder, waist, and hips are varied on a seven-point scale as follows: the shoulders from 1-12/16" to 1-7/16", the waists from 14/16" to 11/16", and the hips from 15/16" to 1-4/16".

No attempts were made to draw body somatotypes as such, the figures not being thin, fat, tall, short, muscular, or asthenic. The only changes in the figures were those described.

E. PROCEDURE

The place of administration of the Body-Image Identification Test varied with the space available. In one instance it was administered on a table at the back of a classroom; in other instances, it was given in a private room. The test was administered to one subject at a time.

As each subject arrived to take the test, a friendly atmosphere was established by asking for the answers to a few of the questions printed on a data sheet: for example, name, age, grade (if up to grade level), how many sisters and brothers, who was older, and with whom he lived at home. This often led to conversation and remarks, frequently revealing and useful for qualita-

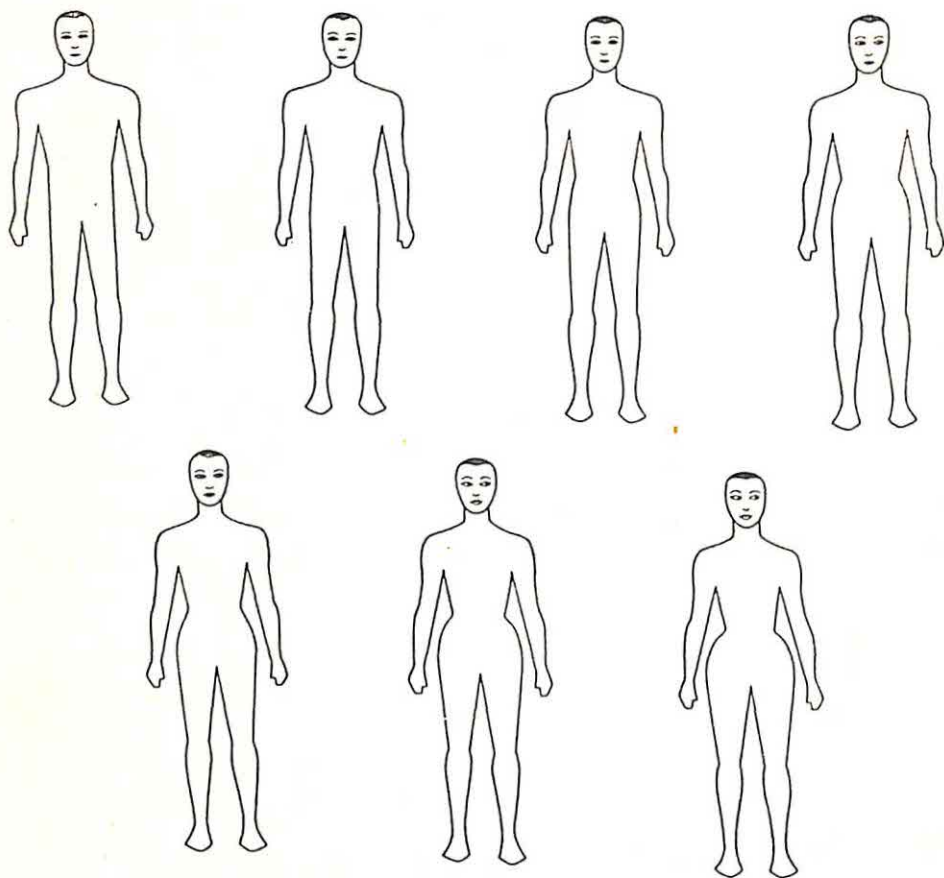


FIGURE 1
WHOLE FIGURES

tive evaluation. All remarks made by the subject and the observations made by the examiner were recorded on the data sheet.

Further information pertinent to each subject (e.g., his peer relations, the nature of the personality disturbance, the treatment history, the type of offense if an offender, court convictions, *IQ*, etc.) was obtained from teachers, psychologists, and others.

Before putting any material on the table, the examiner said, "I have a few pictures to show you and then I would like you to answer a few questions about them." The subjects were not told the purpose of the test in advance, but were told only that they were cooperating in research and that the test results would not affect their school grades in any way.

The first seven four-inch by seven-inch cards were placed on the table facing the subject and facing away from the examiner, who sat opposite the subject.

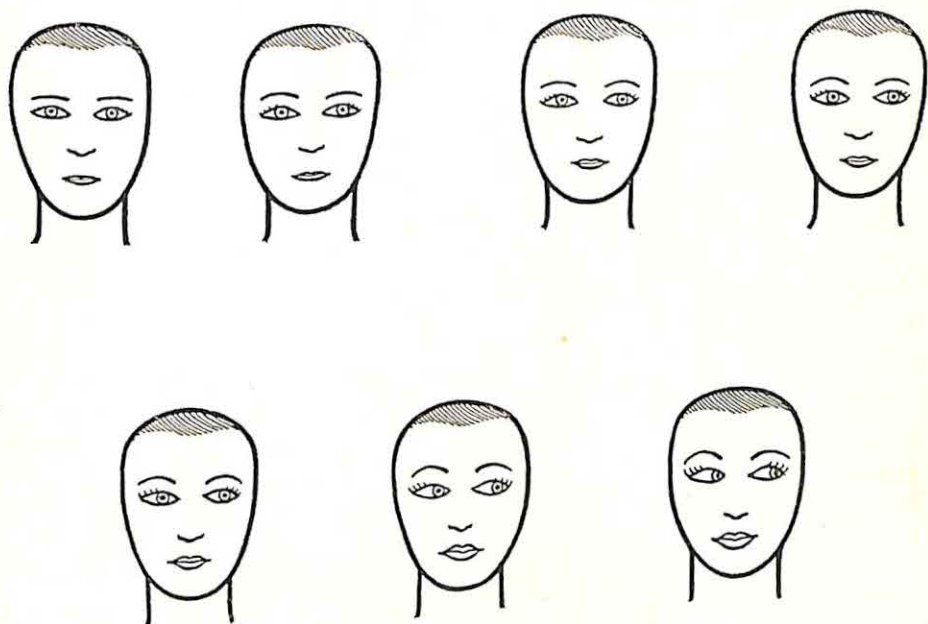


FIGURE 2
FACES³

The cards were always presented in the same random order (3-1-7-4-6-2-5), one series at a time: whole figure, face, shoulders, hips. First, the whole-figure series was presented; and the following questions were asked: (a) Which one is most nearly like you? (b) Which one would you rather be like? (c) Which one is most nearly like your mother? and (d) Which one is most nearly like your father? If the subject indicated that none could be selected, the examiner urged the subject to select one.

The next part of the test had three sections: one series of seven cards for the face, one for the shoulders, and one for the hips. Each part corresponded

³ Faces on original test cards were in proportion to the bodies.

to the same part in the whole-figure series. Each series of seven pictures was presented in the same random order (3-1-7-4-6-2-5) and placed on the table in order from the subject's right to left. The following questions were asked: (a) Which face is most nearly like yours? (b) Which face would you like to have? (c) Which of these shoulders is most nearly like yours? (d) Which shoulders would you like to have? (e) Which of these hips and legs is most nearly like yours? and (f) Which hips and legs would you like to

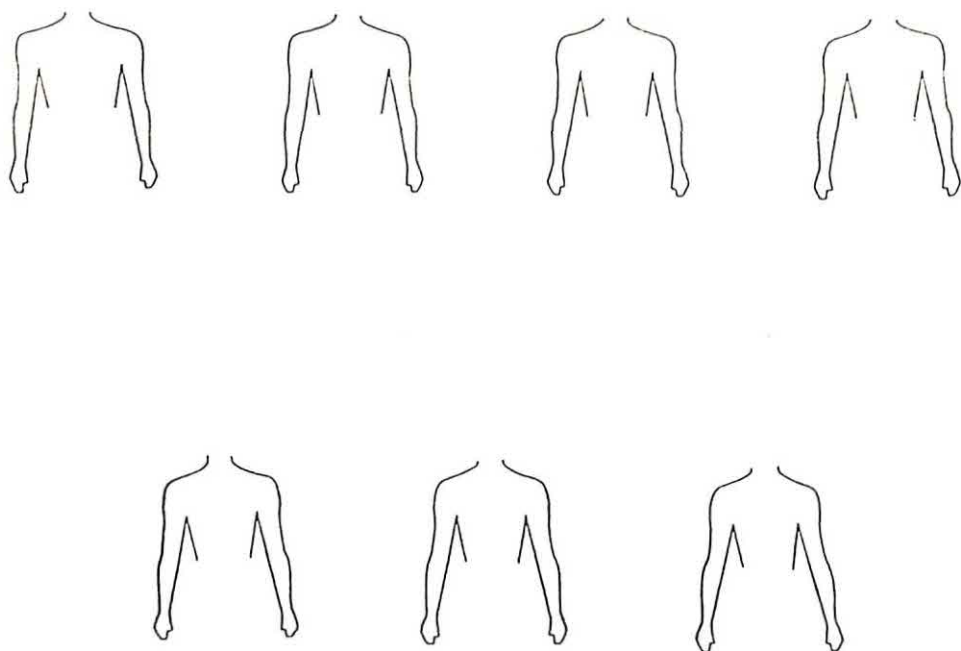


FIGURE 3
ARMS AND CHEST

have? If the subject resisted making a choice, the examiner repeated, "Which would you most nearly like to have?"

After the selections were made, the subject was asked to arrange the seven whole-figure pictures from the left side to the right side, from most-like-boys to most-like-girls. If this instruction was not clearly understood, the subject was asked to arrange the pictures in two piles: the boys in one pile and the girls in the other. This instruction was later changed to "men" and "women" because many subjects were found to have different conceptions of the terms "men" and "boys" and "girls" and "women."

The last question was, "Is there anything you want to tell or ask me about

these pictures?" Usually, the subject would ask what the test was for. The answer to this was "to help find out what people think they look like," and for most this was an adequate explanation.

F. DISCUSSION

Historically, feelings of sex differentiation and sex identification as revealed by body-image studies have been qualitatively and subjectively interpreted. The Body-Image Identification Test is an attempt to devise a more objective

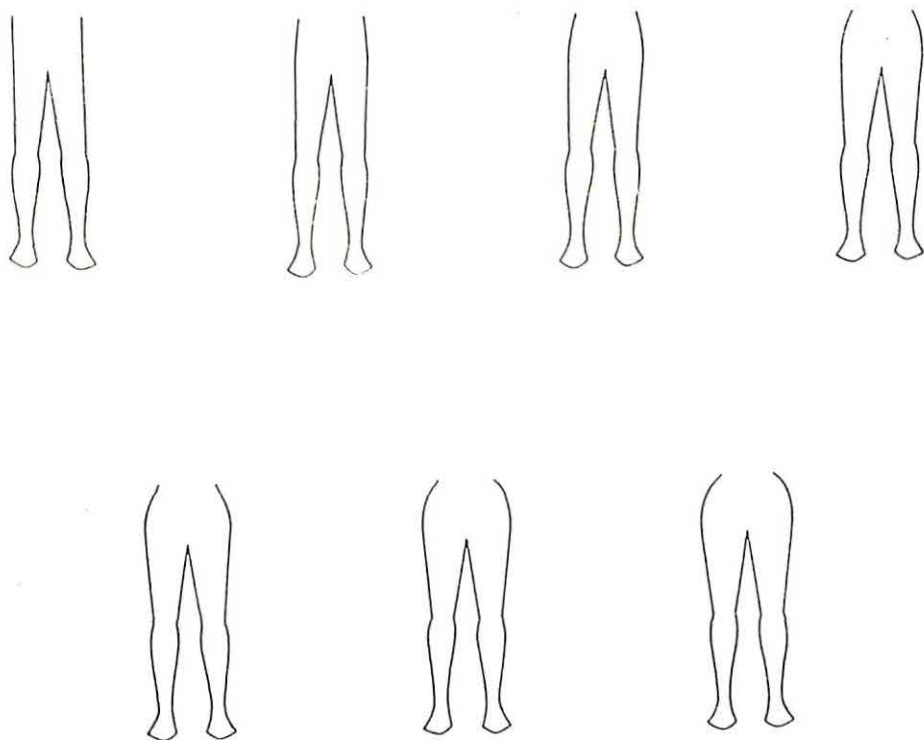


FIGURE 4
HIPS AND LEGS

measure, so that the data of a projective test can be evaluated more uniformly. This test, while making no attempt to measure total body-image concepts, confines itself to that aspect that relates to a subject's feelings of maleness and femaleness; i.e., what body parts are subjectively experienced as the most important, what body parts are emphasized at different age levels, how does a subject look upon and accept his own sex role, and how do these views change

from one stage of development to another (such as from the latency stage through prepuberty and adolescence).

Attempts to reach the conscious and unconscious motivating forces behind one's body image, with the emphasis upon what the subject thinks or feels his body to be and what he would like it to be, are made by evaluating the answers that subjects make on a forced-choice basis from a scale of figure drawings that differ in size in exact amounts. This test calls upon no drawing skills. It measures the amount of satisfaction-dissatisfaction and may reveal either feelings of wholeness and unity of body image or poorly integrated and differentiated split-body image. Feelings of "Can anyone like me?" are related to feelings of body image satisfaction-dissatisfaction. Distorted feelings of femininity-masculinity relate directly to body-image dissatisfaction; however, if a subject desires very little change from what he feels he is, this could be either a measure of satisfaction or a measure of rigidity in the subject's personality. This interpretation depends on further study and more knowledge of the subject.

Body language was used by the children in evaluating their body images. They often looked at and felt their shoulders, hips, and legs. They shrugged their shoulders, shook their legs, and in many ways behaved as if the sensation of body unity were experienced from the outside, as if they were asking and looking for help in determining how one is supposed to feel. One disturbed boy (aged 8:6) asked for a mirror, as if his body image had to be reflected from feelings of others and from the outside exclusively.

This test elicited more intense reaction-formation defensive responses among boys aged 8 to 11 in the disturbed sample. The figures (all front view, nude, and lacking genitals) proved threatening. They were less able to evaluate the silhouetted body shapes objectively than were the other three samples tested, and the drawings seemed to reinforce feelings of castration. This may be a valuable facet of the Body-Image Identification Test and should be explored.

In the Body-Image Identification Test, the subject indicates which whole figure he thinks he looks like, which he would rather look like, which looks most like his mother, and which like his father. Further, the whole figure is separated into parts of face, shoulders, and hips, and the subject is asked to choose which part is most like him and which part he would rather have. Eight of these comparisons are significant ($p < .05$). Table 1 shows two significant differences between the disturbed male group and the normal male group (ages 8 to 11). The hips chosen by the normal group were more feminine than the ones (with respect to the original choice) on the whole figure—

both as (a) to what they think they look like and (b) to what they prefer to look like. The disturbed boys chose more masculine hips in each case. This could be interpreted as restitutive efforts accompanying feelings of loss or body injury on the part of the disturbed males. Also, many disturbed males refused to answer this part of the test, indicating intense feelings of body distortion without restitutive efforts.

In the samples comparing adolescent male slow learners with adolescent

TABLE 1
FREQUENCY AND DIRECTION OF DIFFERENCES FOR MALE DISTURBED vs. MALE NORMAL

(I A—IV A)				(I B—IV B)			
Direction of differences	MD	MN	Totals	Direction of differences	MD	MN	Totals
+	8 (.30)	20 (.69)	28	+	7 (.28)	18 (.62)	25
0	11 (.41)	5 (.17)	16	0	9 (.36)	8 (.28)	17
—	8 (.30)	4 (.14)	12	—	9 (.36)	3 (.10)	12
Totals	27 (1.01)	29 (1.00)	56	Totals	25 (1.00)	29 (1.00)	54
Chi square = 8.665**				Chi square = 7.645*			

Note: I = Whole Figure body parts (Figure 1); IV = Hips (Figure 4); A = Body Image Identification Test question "Which one is most nearly like you?" B = "Which one would you rather be like?" MD = Male Disturbed (ages 8-11) MN = Male Normal (ages 8-11).

* Significant at .05 level.

** Significant at .02 level.

female slow learners, significant differences occurred (see Table 2). The girls did not feel that their mothers appeared more feminine than they themselves did, but thought their fathers appeared more masculine. Many male subjects did, but thought their fathers appeared more feminine than they thought both their mothers and fathers appeared more feminine than they felt themselves to appear. These boys (ages 13 to 17) took extreme views of their fathers' masculinity, either considering them more feminine or more masculine, but few felt that there was no difference between themselves and their fathers. It is possible that adolescent male slow learners have difficulty relating to fathers and cannot look upon them objectively (confusedly placing their male parent at either extreme of the scale in relationship to themselves). All the males preferred to look more masculine than their mothers. In 53 per cent of the cases, the females thought their mothers looked more masculine than the body image they preferred for themselves.

TABLE 2
FREQUENCY AND DIRECTION OF DIFFERENCES FOR MALE SLOW LEARNERS
vs. FEMALE SLOW LEARNERS

(I A—I C)				(I A—I D)			
Direction of differences	MS	FS	Totals	Direction of differences	MS	FS	Totals
+	14 (.70)	7 (.37)	21	+	9 (.43)	1 (.05)	10
0	0 (.00)	5 (.26)	5	0	3 (.14)	2 (.10)	5
—	6 (.30)	7 (.37)	13	—	9 (.43)	17 (.85)	26
Totals	20 (1.00)	19 (1.00)	39	Totals	21 (1.00)	20 (1.00)	41
Chi square = 7.389*				Chi square = 9.042**			
(I B—I C)				(I B—I D)			
+	16 (.80)	5 (.26)	21	+	10 (.48)	0 (.00)	10
0	0 (.00)	4 (.21)	4	0	2 (.10)	0 (.00)	2
—	4 (.20)	10 (.53)	14	—	9 (.43)	20 (1.00)	29
Totals	20 (1.00)	19 (1.00)	39	Totals	21 (1.01)	20 (1.00)	41
Chi square = 12.315***				Chi square = 16.157****			
(II A—II B)				(I A—III A)			
+	3 (.15)	9 (.43)	12	+	12 (.57)	5 (.25)	17
0	12 (.60)	3 (.14)	15	0	7 (.33)	6 (.30)	13
—	5 (.25)	9 (.43)	14	—	2 (.10)	9 (.45)	11
Totals	20 (1.00)	21 (1.00)	41	Totals	21 (1.00)	20 (1.00)	41
Chi square = 9.524***				Chi square = 7.393*			

Note: I = Whole Figure body parts (Figure 1); II = Faces (Figure 2); III = Shoulders (Figure 3); A = Body Image Identification Test question "Which one is most nearly like you?" B = "Which one would you rather be like?" C = "Which one is most nearly like your mother?" D = "Which one is most nearly like your father?" MS = Male Slow Learners (ages 13-17) FS = Female Slow Learners (ages 13-17).

* Significant at .05 level.

** Significant at .02 level.

*** Significant at .01 level.

**** Significant at .001 level.

With no exceptions, female adolescents accepted the father as a masculine figure, and all preferred to look more feminine. This desired body image was much less secure and unified for the male adolescents, some of whom found their mothers more masculine than they themselves would like to be and further found that their fathers seemed either masculine or feminine.

Body-image concept in terms of how a child sees and experiences himself in relationship to his parents of like and opposite sex raises the question of how sex identification is involved with disturbed parental relations, disturbed marital relations, confused role playing, and what is fundamentally influential in evolving the subjective experience of one's own body image and body ego.

One of the two remaining significant comparisons (see Table 2) shows that the face as a body part is better accepted by males than by females. Females wanted to change their faces in either direction, showing dissatisfaction with the face and indicating its importance as a part of the body-image concept. This is likely a culturally determined phenomenon in which great importance is attached to the girl's face in determining her attractiveness to the male. Girls may have learned to displace much of their feelings of dissatisfaction to their appearance.

A comparison of the whole figure with the shoulder part in terms of what the subject thinks he looks like probably does not reflect the situation accurately (see Table 2). Slower males (ages 13 to 17) chose more feminine shoulders than would be expected in relation to the whole figure. The whole figure was selected on the basis of its total impression; but when the shoulders alone were exposed, narrow feminine shoulders were often chosen because, in relation to them, the arms looked larger and more muscular than they did in relation to the broader shoulders, although the dimensions of the arms did not vary. Muscular arms as a variable in masculine-feminine body-image concept was not explored in the figure drawings of the Body-Image Identification Test, therefore, scales could be developed in which the size of the arm varies in relation to shoulder size.

No significant differences were found between the samples of normal males and slow-learning males, indicating that sexual identification and the body-image concept may be a function of mental age and less related to chronological age. Is it possible that the body-image concept as a subjective experience is regressed for slow male learners although they can consciously differentiate? Normal males (ages 8 to 11) thought of their fathers as more feminine than they felt themselves to be or preferred to be. Is it possible that younger boys relate to and identify with the mother figure and place both parents in a feminine role?

The Body-Image Identification Test needs to be developed, validated, and expanded further; but it shows possibilities for quantitatively measuring unconscious and subjectively experienced feelings of body image and body ego. The questions asked seem to relate to and reveal the subject's body-image concept for many areas of sexual identification, indicating the relative values of separate body parts as compared to the whole figure for determining total body image.

G. SUMMARY AND CONCLUSIONS

The purpose of this study was to devise a quantitative test to measure feelings of masculinity-femininity as they relate to body image. It attempts to reach conscious sex-role identification and unconscious motivations and subjective experience of body image and body ego.

Seven silhouette drawings of the human figure were used. Each subject was asked to choose which body and body part seemed most like his, and which body and body part he would prefer to have. He was also asked which whole body was most like that of his mother and which like that of his father. Choices were evaluated on the basis of amount of differences between the way the subject saw himself, his mother, his father, and his separate body parts.

The following conclusions were reached:

1. Normal males identified themselves as having more feminine hips than did the disturbed males, who thought their hips looked more masculine than the hips on the original whole-figure choices.
2. Normal males were able to express a preference for more feminine hips than were disturbed males with respect to their original choices on the whole figure.
3. Male slow learners thought their mothers looked more feminine than themselves, but female slow learners didn't think so.
4. Male slow learners thought their fathers looked less masculine than did female slow learners.
5. Female slow learners preferred to look more feminine than they thought their mothers looked, but boys thought their mothers looked more feminine than they preferred to look.
6. All females thought their fathers were more masculine, but the males placed their fathers uniformly along the scale from most feminine to most masculine, taking extreme views of their father's masculinity.
7. Faces were more important as a body part to female slow learners than to male slow learners, and female slow learners expressed more dissatisfaction

with their faces, wanting more change in either direction than did the male slow learners.

8. The male slow learners saw themselves as having feminine shoulders and the female slow learners identified with masculine shoulders.

9. There were no significant differences between the male slow learners and the male normal samples on any comparison.

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SOCIAL DISTRACTIBILITY OF PREVIOUSLY IRRADIATED FEMALE RHESUS MONKEYS*¹

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A. PROBLEM

For male monkeys exposed in the laboratory to mixed gamma and neutron radiations, for male monkeys exposed in the field to nuclear radiations, and for male monkeys exposed in the laboratory to neutron radiation, decreased social distractibility accruing to prior radiation exposure has been reported (1, 2).

The purpose of the present study is to determine if previously irradiated adult-female rhesus monkeys show a similar decrease in social distractibility. We felt that it would be inappropriate to use an adult-male monkey as the social stimulus because of the probable role that the stage of the menstrual cycle might play in responsiveness. An adult-female rhesus monkey as the social stimulus seemed contraindicated because of the familiarity of the subjects with members of their own kind. We decided to use as a social stimulus a female monkey of a different species: i.e., a Stump-tailed Macaque of the *spesiosa* group.

B. MATERIALS AND METHODS

1. Subjects

Four control monkeys and 11 whole-body-irradiated monkeys served as Ss. These Ss were the female survivors of an exposure to nuclear radiations more than six years earlier. The four control Ss constituted Group 1. The six irradiated Ss that had been exposed to estimated total radiated dosages of 273, 299, or 355 rem were considered together as Group 2; and the five that had been exposed to estimated total radiation dosages of 397, 439, or 512 rem were considered together as Group 3. The training histories of the Ss were nearly identical and included numerous Wisconsin General Test Apparatus tasks.

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¹ This work was conducted at The Radiobiological Laboratory of The University of Texas and The United States Air Force and was supported (in part) by Contract AF 41(657)-382 and The School of Aerospace Medicine.

2. Procedure

The procedure was systematic observations of free-cage behavior and followed that of McDowell, Davis, and Steele (3). Each *S*, during each observation, was confined in a special holding cage ($3' \times 3' \times 3'$) that was constructed of steel bars placed three inches apart, center to center. A wooden cage bed was attached to one side of the cage.

The observer sat eight feet from the special holding cage and recorded on each 10-second mark on a mimeographed category sheet the nature and direction or nondirection of the *S*'s behavior every 10 seconds. Each observation lasted five minutes; so the total frequency count for each *S* for each observation was 30.

The behavioral categories on the mimeographed category sheet included (a) nondirected visual activity; (b) nondirected locomotor activity; (c) manual, oral, or visual responses to *S*'s body parts; (d) manual, oral, or visual responses to the cage parts as manipulanda; (e) visual response to the observer; and (f) orientational response to noises occurring outside the test-room.

Each *S*, over a three-day period, was first observed with no social stimulus present; next, with the adult-female Stump-tailed Macaque present; and again, with no social stimulus present. The social stimulus was visually but not physically accessible as it was placed in a well-lighted holding cage at a distance of three feet from the cage housing the *S* to be observed.

Behavioral stability was considered in terms of the maintenance during each of the last two observations of the balance between total directed activities and total nondirected activities as manifest during the first observation. Total nondirected activity was used to measure that stability. Responses to the social stimulus were measured by determining, for each *S*, the difference between 30 and the total frequency count during the observation with the social stimulus present. Statistical treatment of each set of data involved an analysis-of-variance procedure.

C. RESULTS

Figure 1 shows the mean nondirected activities for the *S*s of each of the three groups during successive days of observation. Condition 1 refers to the first day of observation when no social stimulus was present; Condition 2 to the day of observation with the social stimulus present; and Condition 3 to the last day of observation when again no social stimulus was present. Statistical analysis of the frequency data upon which Figure 1 is based yields a groups-

by-conditions interaction significant beyond the .05 level. The social stimulus produces a marked decrease in the nondirected activities of the control Ss and a considerably lesser decrease for the irradiated Ss of the other two groups.

The mean frequency of overt responses to the social stimulus is 12.75 for the control Ss, 6.00 for one of the irradiated groups, and 7.00 for the other

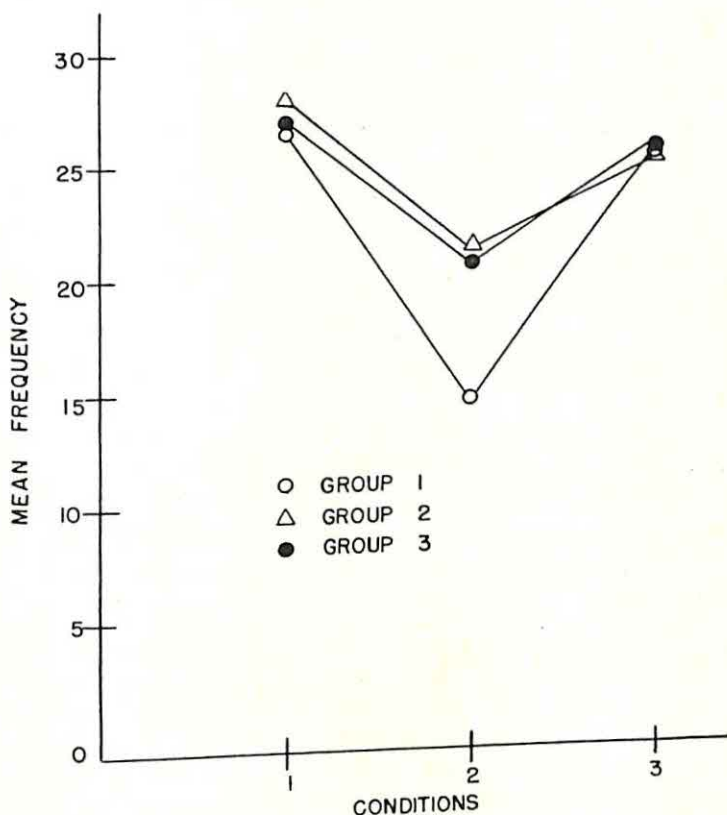


FIGURE 1
MEAN FREQUENCY OF NONDIRECTED ACTIVITIES FOR THE Ss OF EACH GROUP
DURING EACH OF THE THREE DAYS OF OBSERVATION

irradiated group. Statistical comparison of these means yields a difference significant beyond the .01 level.

D. DISCUSSION

The present results argue conclusively for a decrease in social distractibility for female monkeys previously exposed to nuclear radiations. Such results,

considered together with the previous findings on irradiated male monkeys (1, 2), demonstrate the generality of the phenomenon of decreased social distractibility in irradiated rhesus monkeys.

E. SUMMARY

Each of four control monkeys and 11 irradiated female rhesus monkeys, over a three-day period, was first systematically observed with no social stimulus present; next, with a female Stump-tailed Macaque present; and again, with no social stimulus present. The social stimulus was visually but not physically accessible, being placed in a cage at a distance of three feet from the cage in which experimental Ss were observed.

The presence of the social stimulus disrupts the free-cage behavior of control subjects significantly more than it does that of irradiated subjects. The control subjects show significantly greater direct responsiveness to the social stimulus than do the irradiated subjects.

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EXTINCTION TESTS WITH MALE RHESUS MONKEYS AFTER CHRONIC EXPOSURE TO FAST-NEUTRON RADIATION*¹

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A. PROBLEM

Previous research has shown that an extinction criterion of 50 milliminutes significantly separates normal rhesus monkeys and monkeys given laboratory whole-body exposure to mixed neutron-gamma radiation. The separation is in favor of facilitated extinction for irradiated Ss (2). The results were replicated with monkeys exposed to nuclear radiations in the field (2).

The purpose of the present study is to determine if adult male monkeys exposed to chronic fast-neutron radiation also show facilitated extinction over their normal controls.

B. METHODS

1. *Subjects*

Nine rhesus monkeys, ranging in age from approximately 7 to 9 years, served as Ss. Four of these Ss had been exposed to chronic fast-neutron radiation more than five years earlier. They had at that time been given a 24-hour whole-body exposure every four days at 87.2 mrep/hr until a total dose of 583 rep was achieved. The six control Ss had been sham exposed during the same period. The training histories were identical and included a number of Wisconsin General Test Apparatus (WGTA) tasks.

2. *Apparatus*

The testing of Ss in this study was done in a modified version of the WGTA with the animal-carrying cage serving as the holding cage during testing. A stimulus tray holding two food wells, spaced 12 inches apart (center to center) was used. In contrast to the previously reported work, for which two test objects were used, the test object in the present study was a single, square, orange-painted wooden block.

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¹ This work was conducted at The Radiobiological Laboratory of The University of Texas and The United States Air Force and was supported (in part) by Contract AF 41(657)-382 and The School of Aerospace Medicine.

3. Procedure

Each *S* was tested 24 trials each day for three days on response latency to the stimulus block presented randomly over the left and right food wells. Food was under the block only on the first day of testing. If, on any trial, the *S* failed to respond within 50 milliminutes, the trial was terminated and the next trial was initiated. Response latency measures were obtained by modifying the WGTA, so that a clock was activated when *E* raised the forward opaque screen. The clock stopped when the *S* pushed a stimulus block from the top of a food well.

As in the previous research, the *Ss* of the two groups were compared on a trials-to-extinction criterion and on trials-at-extinction criterion on the first day of extinction testing. In addition, they were compared on median response latencies over the three days of testing.

C. RESULTS

Only one of the *Ss* showed a response latency as long as 50 milliminutes during the first day of testing when each response was food rewarded. The *Ss* of the two groups failed to differ on the number of trials prior to a response latency of 50 milliminutes on the initial day of extinction testing. The control *Ss*, however, during the same day of testing showed a mean frequency of 9.60 trials at the extinction criterion. An analysis of variance shows this mean frequency to differ significantly (at the .025 level) for irradiated *Ss*.

Figure 1 shows the mean median response latencies for the *Ss* of the two groups during the day of food-rewarded testing (Day 1) and the two days of extinction testing (Days 2 and 3). Analysis of variance shows an effect for days significant beyond the .01 level and a groups-by-days effect significant beyond the .05 level. Median response latencies increase during extinction testing, and increase to a higher level for the control *Ss* than they do for irradiated *Ss* on the initial day of extinction testing.

D. DISCUSSION

The results of the present study are in contrast to those of the previous report of facilitated extinction for irradiated *Ss* (2). The adult-male monkeys of the current study not only fail to manifest facilitated extinction, but show in fact slower extinction than do their normal controls.

Procedural differences between this study and the earlier one conceivably could account for the differences in test results. An alternative hypothesis is that the findings of the present study may be peculiar to whole-body exposure

to fast-neutron radiation. We have demonstrated that the irradiated *Ss* of the present study weigh significantly less than do their normal controls (3) and are significantly more responsive to inaccessible food than are their normal controls (1). Similar differences were not manifest in the groups used in the previous study. In other words, the physiological factor or factors responsible for stunting of growth in these *Ss* could render them more resistant to extinction than their controls.

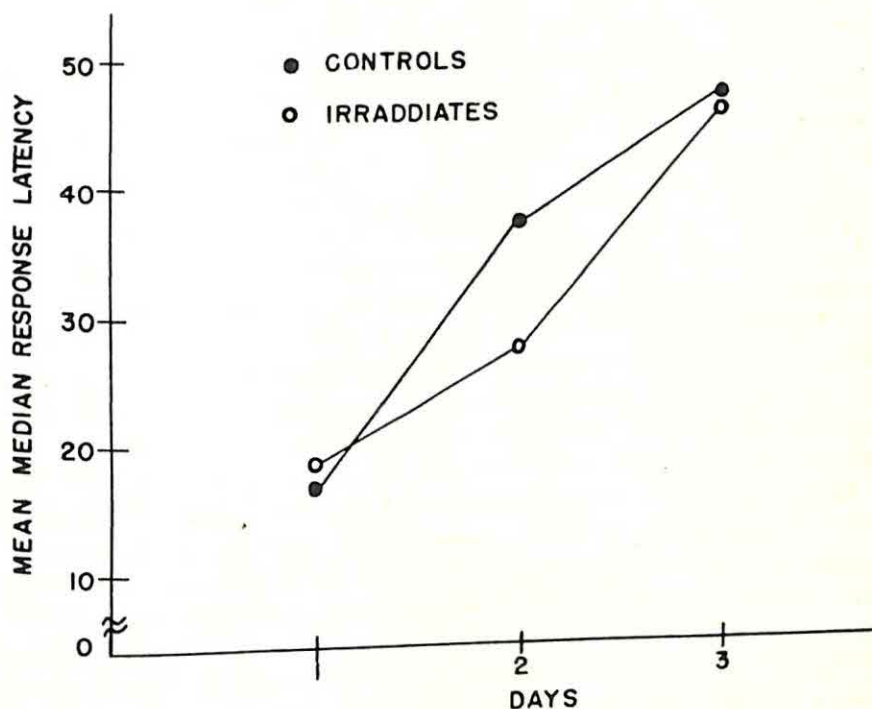


FIGURE 1
MEAN MEDIAN RESPONSE LATENCIES FOR THE *Ss* OF THE TWO GROUPS
DURING EACH OF THE THREE DAYS OF OBSERVATION

E. SUMMARY

Five control monkeys and four whole-body-irradiated monkeys, previously exposed to chronic fast-neutron radiation, were tested 24 trials per day for three days on response latency to a single stimulus object. Response was rewarded by food only on the first day. Testing was terminated on each trial if the *S* failed to respond within 50 milliminutes. Control *Ss* show significantly

more trials at 50 milliminutes during the first day of extinction testing than do irradiated Ss. In addition, median response latencies increase to a higher level for control Ss than for irradiated Ss on the initial day of extinction testing.

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PROBABILITY LEARNING IN YOUNG CHILDREN: THE BINARY CHOICE PARADIGM*¹

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A. INTRODUCTION

In a recent paper (9), Lewis, Wall, and Aronfreed make the point that the appearance of maximization in the binary-choice performance of young children might rest less on conscious decision making than on a conditioning phenomenon. Performance in the binary-choice task usually has been associated with a variety of strategies, such as probability matching and maximization. If these strategies or conscious decision-making processes are significantly involved in the behavior of young children, then those variables usually associated with increases in cognitive capacity should result in superior binary-choice performance. One such variable, differential instructions concerning the value and composition of the binary-choice task, was tested by Weir (15) on young children. In this task, if children's behavior involves decision making, one would expect differential instructions to affect subsequent performance. In fact, this has been demonstrated to be true for adults (4, 5, 10). Weir's study failed to show any effect that could be attributed to the differential instructions; thus it appears that, at least for young children, instructions play a minimal role in determining their binary-choice behavior.

Two other variables usually associated with increases in cognitive capacity are age and intelligence. The purpose of this paper is to demonstrate that increases in age and intelligence do not result in superior binary-choice performance and, in fact, can result in poorer performance. In the first experiment age was varied, and its effect on binary-choice performance was studied; in the second experiment, intelligence was varied.

B. EXPERIMENT I²

1. *Method*

a. Subjects. Twenty-five children, 14 girls and 11 boys, from the Fels Nursery School were used for the younger group. Their ages varied from 3

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¹ The study was supported by National Institute of Mental Health Grant M-1260.

² Mrs. Rhoda Lewis is to be credited for the data collection of Experiment I.

to 5 years. Fifty-eight first and second graders, 29 girls and 29 boys, from a public elementary school constituted the older age group. Their ages varied from 6 to 8 years.

b. Apparatus. The learning task was a two-choice probability-learning problem consisting of a deck of 100 cards. Identical pictures of rabbits and of birds were randomly distributed in blocks of 25 cards in the ratio of 70 per cent rabbits and 30 per cent birds.

c. Procedure. Each *S* was told that the purpose of the game was to guess which animal (bird or rabbit) would appear on the next card. The deck of cards was held face down, and after each guess the top card was shown to the child. After a second or two, the card was removed from *S*'s sight. Whenever *S* guessed correctly, he was reinforced by *E*'s saying either "Good," "Fine," or "That's good." Since *S* saw whether he had guessed correctly or not, the reinforcement was not contingent on his response. After 100 trials, each *S* was returned to his classroom and was asked not to tell the other children what had occurred.

d. Measures. Two measures of binary-choice performance were obtained: (a) the total number of responses to the most frequently reinforced response (in this case, rabbit) across all 100 trials and (b) the total number of responses to rabbit across the last 20 trials.

2. Results

By age group and sex, Table 1 presents the total number of responses to rabbit across all trials and the last 20 trials.

TABLE 1
MEAN PER CENT OF RESPONSES TO RABBIT BY AGE AND SEX

Sex	N	Nursery (3-5 years)		First and second grade (6-8 years)		
		All trials	Last 20 trials	N	All trials	Last 20 trials
Boys	11	68.2**	65.0	29	55.3	61.0
Girls	14	60.3**	65.1**	29	55.3	59.1
Total	25	63.9***	65.1*	58	55.3	60.1

* $p < .08$.

** $p < .01$.

*** $p < .002$.

With the Mann-Whitney *U* test (11), the *p* value associated with a mean performance value indicates that there is a significant difference between the two age groups for that particular comparison. For both measures of per-

formance, the data indicate that the younger children generally perform significantly better than do the older ones.

C. EXPERIMENT II³

1. Method

a. Subjects. One hundred fifty third-grade children, 72 males and 78 females, from a public elementary school were used in this experiment. Based on their performance in Grades 1 and 2 and on the California Mental Maturity Test, the children previously had been assigned to one of three classes. Table 2 presents the distribution of children in the three classes.

TABLE 2
SAMPLE DISTRIBUTION BY SEX AND INTELLIGENCE

Sex	N	Intelligence		
		Above average	Average	Below average
Boys	72	22	27	23
Girls	78	26	33	19

b. Procedure. The procedure was the same as that used in Experiment I except that each child received only 30 trials. It was also different in that cats and dogs replaced the birds and the rabbits in the deck of cards. The ratio of cats to dogs was 70:30 (or 21 cats and nine dogs in the 30-card deck).

2. Results

Table 3 presents the performance data by sex and intelligence. A Kruskal-Wallis one-way analysis of variance test (11) indicates that, so far as *S*'s proportion of responses to cat across all 30 trials is concerned, the three groups

TABLE 3
MEAN PER CENT OF RESPONSES TO CAT ACROSS 30 TRIALS BY SEX AND INTELLIGENCE

Sex	N	Intelligence		
		Above average	Average	Below average
Boys	72	49.9	49.5	54.7
Girls	78	49.7	52.4	53.8

were not drawn from the same population ($p < .02$ for girls; $p < .01$ for boys). Individual Mann-Whitney *U* tests (11) show that, for both boys and girls, the below-average group performs significantly better than does the above-average group ($p < .01$).

³ The data reported in this study are part of the data gathered in a larger study to be reported. Miss Jerry Agate is to be credited for the data collection of Experiment II.

D. DISCUSSION

The results of both Experiments I and II agree with those of other binary-choice experiments in which age or intelligence was varied. Crandall, Solomon, and Kellaway (2), Stevenson and Weir (13), and Jones and Liverant (6), comparing various age groups, have reported that younger children show higher asymptotic levels of performance than do older children. While the authors did not vary intelligence directly, Stevenson and Zigler (14), comparing normal and feeble-minded children, found that feeble-minded children maximize their successes; normal children do not.

It appears that those variables usually associated with conscious decision making are not necessarily involved in achieving high asymptotic levels of performance in the binary-choice problem. In fact, conscious decision making or problem solving may be a disadvantage in solving a binary-choice problem. In a sequential analysis of children's behavior, Kessen and Kessen (7) and Crandall *et al.* (2) report that older children, as compared with younger children, seem to try to find some type of sequential patterning. The results of the studies cited indicate the attempt at problem solving reduces children's performance on the task. The results appear to indicate that, in an unsolvable problem, conscious decision making and problem-solving sets may result in poorer performance than does some minimum cognitive behavior.

Part of the confusion surrounding binary-choice performance has arisen from the assumption that *S*'s behavior should reflect a desire to receive a maximum amount of reinforcement. Because of the random nature of the binary-choice problem, it also has been assumed that the maximization strategy (choosing the most frequently reinforced event on every trial) is the best solution for the problem, and therefore would be the strategy that organisms would choose. The higher the asymptotic levels of performance, the greater the degree of solution. On the assumption that maximization is the ideal strategy that every organism tries to achieve, the fact that animals and young children reach higher performance levels than adult human *S*s is difficult to explain.

This difficulty centers in the unreal correlation between high asymptotic performance levels and degree of solution. Maximization, which has been described as the most ideal strategy, is often best achieved by a minimum of cognitive capacity. The low levels of performance of those human *S*s seeking a solution paradoxically reflect poor solutions. To demonstrate further the disparity between the anticipated behavior of *S*s and how they act, one needs to look only at Brackbill's and Barvos' and Siegel's findings (1, 12). Contrary

to expectation, the foregoing authors found that Ss preferred to predict correctly the event least likely to occur rather than the event most likely to occur. Clearly, this behavior does not lead to maximization.

Finally, one must recognize the fact that one cannot state what solution is best for an unsolvable problem. When a task (at least the binary-choice task) is unsolvable, the best solution may be found through some type of noncognitive, nonproblem-solving process, like simple instrumental conditioning. In a recent review of binary-choice performance, Lewis (8) attempted to demonstrate that simple instrumental-conditioning parameters could account for binary-choice performance of animals.

In summary, the author proposes that binary-choice behavior need not involve a conscious decision-making process resting on large amounts of cognitive capacity; and that, for naïve organisms, the process is essentially a conditioning phenomenon. For the animal, the conditioned response is the selection of one event instead of another with the rate and the degree of conditioning dependent on those parameters usually associated with simple instrumental conditioning. For children, the problem becomes increasingly dependent on factors other than those associated with simple instrumental conditioning. Even the behavior of older children and adults does not rest solely on cognitive variables. Derks (3) has shown that the reduction of decision time (the time the subject has to make a choice) proves to have no adverse effect upon performance in this task. The inability of differential instructions, the lack of age and intelligence variables, and the absence of any real attempt at problem solving, point to the strong possibility that the superior performance of young children in a binary-choice problem reflects a minimum of conscious decision making in their behavior.

E. SUMMARY

Two experiments were performed to demonstrate that increases in age or intelligence do not result in superior binary-choice performance and can result in poorer performance. The results of Experiment I demonstrate that 3-5-year-old children show higher levels of performance than do 6-8-year-old children. The results of Experiment II demonstrate that children with below-average intelligence show higher levels of performance than do children with above-average intelligence. These results are discussed in terms of their implication for binary-choice learning theory. Briefly, it is proposed that binary-choice behavior need not involve a conscious decision-making process resting on a large degree of cognitive capacity.

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TWO SCALES FOR PARENT EVALUATION*

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A. INTRODUCTION

In 1957 two 50-item Parent Evaluation Scales, one for *father* and one for *mother*, were constructed for use in a study of ideological similarity between college-age subjects and their parents (1). In 1959 these scales were re-edited and used in a replication study at the high school level (2). While test-retest reliabilities were reasonably satisfactory, ranging (on different administrations) from .77 to .97, the lengths of the scales were burdensome. In view of this factor, the scales were revised and shortened to 26 items each. They are now published for use by other investigators who may need such instruments to assess attitudes toward parents.

B. METHOD AND SUBJECTS

Procedures used in constructing the original scales have been described elsewhere (1, 2). Subjects for the present revisions were 104 college students who had lived with their natural parents throughout their lives or until shortly before entering college. They were given the original 50-item scales twice, with approximately 30 days between administrations.

Based on two criteria, 24 items were eliminated from each scale. The criteria were (a) test-retest reversal frequency and (b) high-low response agreement. To determine test-retest reversal frequency, each item was given a reversal score: that is, the total number of times it elicited a response on the second administration opposite to that elicited on the first administration. To determine high-low response agreement, subsamples of high-scoring subjects and low-scoring subjects were selected, and each item was examined for its discriminative power. The discriminating power of each item was determined

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by tabulating the number of times it was used by the high-scoring subsample subjects to indicate a favorable parent quality, and by the low-scoring subsample subjects to indicate an unfavorable parent quality. For example, in the revised *mother* scale, Item No. 15, "She has tried to dominate everyone, including me," is answered negatively by virtually all of the high-scoring subjects; but is answered negatively by significantly fewer of the low-scoring subjects. Items were ranked from high to low on the basis of their discriminative powers. For each scale, the 26 items having the greatest discriminative powers and lowest reversal scores were retained for the revised scales.

C. RESULTS

The revised 26-item scales were given and repeated in varying combinations to four college-age samples of 42, 54, 64, and 84. There was no selection of students based on length of time with natural parents or with foster parents. The time between administrations was approximately 30 days. Subjects recorded their responses on IBM cards.

Subjects responded to the items under one of two sets of directions: (a) true-false or (b) six-position rating. True-false directions were as follows:

Mark answer space one if the statement is true. Mark answer space two if the statement is false, or mostly false.

Six-position rating directions were as follows:

Mark answer space one if statement is completely false; answer space two if statement is moderately false; answer space three if statement is slightly false; answer space four if statement is slightly true; answer space five if statement is moderately true; answer space six if statement is completely true.

The methods of scoring are as follows. For the true-false responses, each positive statement is credited with one point if marked "true," and each negative statement is credited with one point if marked "false." The highest possible score is 26; the lowest possible score, zero. For the six-position rating responses, each positive statement is credited the quantity marked; each negative statement is credited with the reciprocal of the quantity marked: that is, for a negative statement, Choice No. 1, meaning "completely false," is credited to the subject's score as six points; Choice No. 6, meaning "completely true," is credited as one point. The lowest possible score is 26; the highest possible score, 156.

Test-retest Pearson r 's for the true-false scales are as follows: *mother*, .93; *father*, .91 ($N = 84$). Test-retest Pearson r 's for the six-position rating

scales are .92 for *mother* and .97 for *father* ($N = 42$). Kuder-Richardson reliabilities for the true-false scales are .86 for *mother* and .88 for *father* ($N = 202$). Odd-even r 's for the six-position rating scales are .90 for *mother* and .94 for *father* ($N = 160$). All Kuder-Richardson reliabilities and odd-even coefficients are slightly higher for the second administration than for the

TABLE 1
THE MOTHER SCALE

No.	Item
1.	She always made me feel free to discuss problems concerning "boy-girl" relationships without feelings of guilt or embarrassment (+, 2, .68).
2.	I enjoy being with her because she is warm and affectionate (+, 5, .68).
3.	She has made our home cheerful by her presence (+, 5, .73).
4.	She has shown little embarrassment or reluctance in talking to me about problems dealing with sex (+, 2, .58).
5.	She has taught me many useful and creative things by working with me in a friendly, helpful way (+, 5, .66).
6.	She has helped me understand that sexual development is a normal process that goes along with growing up (+, 2, .66).
7.	She gives me the impression that she feels being a mother has made a slave of her, and that she looks upon herself as a martyr (-, 6, .68).
8.	She has always looked forward to the future with confidence (+, 6, .69).
9.	She has always tried to be sure that I am at fault before punishing me (+, 4, .64).
10.	Rather than resort to punishment, she has always preferred to talk things over with me (+, 3, .57).
11.	She has always been sympathetic and understanding when I have felt discouraged and troubled (+, 1, .85).
12.	She has been firm in her discipline without being harsh or unkind (+, 4, .68).
13.	She has often compared me unfavorably with others (-, 1, .53).
14.	She has always given me a chance to "air my grievances" when we have disagreed (+, 3, .66).
15.	She has tried to dominate everyone, including me (-, 5, .88).
16.	She has always shown pleasure in sharing my experiences, but has never tried to pry (+, 3, .69).
17.	She has had a genuine interest in my future, but has never tried to set my goals for me (+, 3, .58).
18.	She is so prudish about sex that I have never felt free to show any interest in the subject in her presence (-, 2, .71).
19.	She has always encouraged me to use my own judgment and make my own decisions (+, 3, .61).
20.	She has always had a great deal of patience, even in trying situations (+, 4, .61).
21.	She has always been optimistic about life in general (+, 6, .52).
22.	She has tended to be adversely critical of my friends (-, 3, .64).
23.	She has advised me wisely about socially accepted standards of conduct between men and women without making me feel insecure and afraid of the opposite sex (+, 2, .71).
24.	She has constantly worried about me and tried to keep me "tied to her apron strings" (-, 3, .64).
25.	She has been so insistent that I excel in my school work I have developed an unusual anxiety about grades (-, 3, .68).
26.	I have always felt free to bring my friends home because she has always made them welcome (+, 5, .81).

first. The last four coefficients were calculated on the basis of scores secured on the first administration.

Although the reliability coefficients tend to be slightly higher for the six-position rating responses than for true-false responses, it seems doubtful that (for most purposes) the slight superiority warrants the use of the more-involved rating response and scoring procedure.

The two scales are given in Tables 1 and 2. After each item the plus or

TABLE 2
THE FATHER SCALE

No.	Item
1.	In punishing me he has always been fair and just (+, 4, .82).
2.	I have always been able to discuss my problems with him (+, 1, .82).
3.	He has tended to be quarrelsome and sometimes abusive (-, 5, .73).
4.	In some ways he has acted like a petty tyrant (-, 5, .72).
5.	His outbursts of temper have often frightened me (-, 5, .66).
6.	He has made me feel that I am important to him as an individual (+, 1, .90).
7.	He has always shown faith in my ability to make decisions (+, 3, .74).
8.	He has a good sense of humor, but has never used it to ridicule me (+, 5, .82).
9.	He has caused our family anxiety and embarrassment on quite a few occasions (-, 5, .66).
10.	He has always been able to control his temper and has seldom been upset by trifles (+, 6, .63).
11.	He has almost always opposed my ideas, and acts as if he is the final authority on everything (-, 3, .90).
12.	He has always seemed to feel that being a father is satisfying and important (+, 6, .78).
13.	He has always been as financially generous with our family as his income would permit (+, 5, .74).
14.	He has always made me feel that he wants me to live my life to please him (-, 3, .71).
15.	He has never felt that all young people are wild and immoral (+, 6, .77).
16.	He has sometimes been so unkind to me that I have wanted to leave home (-, 1, .85).
17.	He has always helped in planning family outings and other fun activities (+, 5, .69).
18.	He has harped constantly on my failures and shortcomings (-, 3, .85).
19.	He likes my friends and has always made them feel welcome in our home (+, 5, .72).
20.	He has helped me develop wholesome attitudes toward sex (+, 2, .57).
21.	He has always guided me—never tried to rule me (+, 3, .62).
22.	Even when I have been doing my best to please him he has criticized me (-, 3, .45).
23.	Very seldom has he punished me or "bawled me out" in front of my friends (+, 5, .64).
24.	He has always tried to make me feel stupid when I didn't agree with him on religious and political matters (-, 3, .75).
25.	He has always preferred talking things over to dealing out punishment (+, 3, .59).
26.	He has always taken equal responsibility with my mother in deciding upon and carrying through with discipline (+, 3, .62).

minus indicates directionality, the one-digit number indicates the content category into which the item falls [(1) acceptance, (2) attitude toward sexuality, (3) responsibility, (4) consistency, (5) warmth, and (6) outlook on life]; and the two-digit number indicates the biserial r for the item, based on true-false responses.

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THE FIRST CHIMPANZEE DRAWINGS*

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A. INTRODUCTION

In his definitive work on primate art, Morris (7) states that primate art began in 1913 and evolves a theory to explain its origin at that time. I would like to call attention to an earlier instance of ape art and suggest a broadening of Morris's theory.

Morris writes:

. . . in 1913, Mrs. Nadie Kohts . . . began a detailed study. . . . The Kohts' volume includes photographs of chimpanzee scribbles and compares them with those of the child. These Russian ape drawings must have been executed before 1916 and are therefore the earliest ones known.

Morris concludes his history of ape art as follows:

That it should have blossomed at the present time is no accident, for both the worlds of science and art were ripe for it. The former had arrived at a point where, in zoological spheres, objective experimental studies of animal behavior patterns are flourishing, thanks to the concerted efforts of the comparative ethologists and the animal psychologists. The art world, on the other hand, has experienced wave after wave of increasingly extreme reactions against the fading, traditional, communicatory functions of painting. As a result, human painting today has become increasingly abstract and has returned motivationally to a state similar to that found in the primates, namely pure aesthetic experimentation. With zoology and art in these phases, the stage was set.

The theory explaining the emergence of ape art around the time of World War I is plausible, but Morris has overlooked some evidence that to some extent contradicts it.

B. OVERLOOKED EVIDENCE

Garner (4) writes of a chimpanzee:

The most sagacious specimen of the race that I have been brought in contact with is Consul II, who is now an inmate of the Bellevue Garden

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in Manchester, England. . . . When Consul is furnished with a piece of chalk he begins to draw some huge figure on the wall or the floor. He never makes attempts to make a small design with chalk, but if given a pencil and paper, he executes some peculiar figure of smaller design. Those made with the chalk or the pencil are usually round or oval in shape, but if given a pen and ink, he at once begins to make a series of small figures containing many acute angles. Whether these results are from design or accident I cannot say, but he appears to have a well-defined idea as to the use of the instrument. Whether he can distinguish between writing and drawing I am unable to say.

Unfortunately, no more information is forthcoming.

Garner's work is obscure because he used naturalist's methods in an uncontrolled way; so his books mostly have been ignored and, when not ignored, disparaged [e.g., Langer (5), Schaller (9)]. However, while the criticisms leveled at Garner's work are accurate, it should be remembered that he was a pioneer in primate ethology and that many of his findings have been verified by more scientific observers. Much can still be learned from his two books (3, 4) as well as from those of Marais (6), whose suggestive work has also been largely overlooked.

While Morris's theory of the steady rise in scientific and artistic interest in ape art since World War I remains essentially unaffected, question arises as to why the first recorded instance of ape art should have occurred in the 1890s. A relevant fact might be that the 1890s marked the heyday of naive anthropological evolutionism [e.g., Darwin (2), Romanes (8)]. Some observers felt that anything man could do the apes could do, though perhaps not as well and, therefore, for the first time in history, observers were alert for signs of behaviors in apes that were previously considered exclusively human. As Boring (1) puts it, "Romanes . . . was seeking to find accounts of the highest levels of intelligence in animals in order later to demonstrate the mental continuity from animals to man." If this explanation is correct, it may be that interest did not arise in the 1890s because the artistic world was not ready till the advent of abstract and cubist painting shortly before World War I.

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THE RELATIONSHIP BETWEEN WECHSLER INTELLIGENCE
QUOTIENTS AND PARSONS LANGUAGE-
SAMPLE SCORES OF MENTALLY
RETARDED CHILDREN*

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FRANCES DEGEN HOROWITZ¹

A. INTRODUCTION

Language measures play a large part in the evaluation of intelligence. Indeed, the vocabulary-test score on the Stanford-Binet correlates well enough with the full score for it to constitute, by itself, a short form of the Stanford-Binet (1). Yet, the desideratum in the definition of language is for it to encompass more than vocabulary; for it to be something other than another way of speaking of intelligence. Like intelligence, however, the definition must be, ultimately, operational. The nondefinitional meanings or the validity of the term will be a function of its relationships. If language can be measured so that the scores can be used predictively for behavior in ways that *IQ* scores cannot, then language will have meaning apart from *IQ*.

Until recently the measurement of language, particularly on retardates, had not been extensively explored (4). One of the recent attempts is the Parsons Language Sample (PLS), modeled on a system of language analysis suggested by Skinner (2). The test is fully described elsewhere (3). Briefly, it comprises six subtests (Tact, Echoic, Intraverbal, Echoic Gesture, Comprehension, and Intraverbal Gesture). The first three subtests combine to give a vocal subscore (PLS-V); the last three combine to give a nonvocal subscore (PLS-NV). The two subtests yield an unweighted mean score (PLS-M). All PLS scores are reported in *T* scores and the higher the score, the more items passed on the test.

Test-retest reliabilities on the PLS (two-and-a-half to four months inter-

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¹ This study was conducted while the author was a guest research associate with the Parsons Research Project: A Language and Communication Program for Mentally Retarded Children. This Project was, at the time, supported by the National Institute of Mental Health, Grant OM-111. The author wishes to express appreciation to Drs. Joseph Spradlin and Gerald Siegel for their interest and cooperation. The Parsons Language Sample data used here were originally gathered under the direction of Dr. Spradlin.

val) range from .51 to .96 on the vocal subtest, .95 to .97 on the nonvocal subtest, and .92 to .992 on the entire-scale score. The test was originally developed as a criterion measure to aid in the selection of retarded Ss in a larger research endeavor. All Ss tested were residents of the Parsons State Hospital and Training Center at Parsons, Kansas, a treatment-care center for nonmultiply handicapped, mentally retarded youngsters, ages 6 to 21 years.

The major interest of the present study was to determine the degree of relationship between the PLS subtest and total scores with scores from a standard intelligence test. If PLS scores and standard-*IQ*-test scores correlate highly, then it is possible only one of the two instruments is sufficient for selection and/or prediction. If, however, the tests are somewhat independent, then each assessment can be thought of as sampling a different set of behaviors. The usefulness of each test can then be further evaluated. These questions are more crucial to an evaluation of the PLS since there is more known about the standard *IQ* score. If a PLS score can be predicted from the *IQ* score, there is no point to administering the PLS. Thus, this study was done to evaluate the relationship between *IQ* and the Parsons Language Sample.

B. PROCEDURE AND SUBJECTS

For 157 Ss in the institution there were both PLS test results and Wechsler Intelligence test results (Wechsler-Bellevue, WAIS, or WISC). These Ss were divided into two age groups: 8-13 and 14-16, hereafter referred to as younger and older. From each age group a random sample of 40 Ss was drawn. Table 1 indicates the mean age and test scores for each group.

TABLE 1
MEAN AGES AND TEST SCORES OF SUBJECTS

Subjects	Age	WB-C	WB-V	WB-P	PLS-M	PLS-V	PLS-NV
Younger	11.38	55.55	58.20	59.10	57.85	58.50	57.16
Older	15.18	54.65	56.68	57.82	59.38	61.34	57.67
All	13.28	55.10	57.44	58.46	58.62	59.92	57.42

Pearson *r*'s were run within each age group for each of the following pairs of scores: Wechsler-Bellevue composite (WB-C)² and Parsons Language Sample mean (PLS-M), Wechsler-Bellevue verbal (WB-V) and Parsons Language Sample vocal (PLS-V), and Wechsler-Bellevue performance (WB-P) and Parsons Language Sample nonvocal (PLS-NV).

² While different Wechsler scores were used for different Ss (Wechsler-Bellevue, WAIS or WISC), WB will be used as a convenience to designate the intelligence-test scores.

C. RESULTS

Lines 1 and 2 of Table 2 indicate that all correlations for younger and older *Ss* were significant at less than the .005 level of confidence except those between WB-P and PLS-NV. Using a Fisher z transformation, the author tested the hypothesis that the correlations for each measure were from the same population for the two age groups. The test indicated that the hypothesis could not be rejected. The correlations for each measure were averaged for the two age groups and converted to r by using the z transformation values. The resulting correlations are shown on the third line of Table 2.

TABLE 2
PEARSON r CORRELATIONS

Subjects	WB-C, PLS-M	WB-V, PLS-V	WB-P, PLS-NV
Younger	.48*	.70*	— .18
Older	.61*	.83*	— .03
All <i>Ss</i>	.55*	.75*	— .10

* Significant at less than the .005 level of confidence.

The mean correlation of .55 for WB-C and PLS-M and the mean correlation of .75 for WB-V and PLS-V were significant at less than the .005 level of confidence. The mean correlation of —.10 for WB-P and PLS-NV was not significantly different from zero.

In addition to the above correlations, but not shown in tabular form, a correlation of .008 was obtained for PLS-V and PLS-NV scores among younger *Ss*. For older *Ss* the correlation on this same measure was .013. These two correlations were not significantly different from zero. The average correlation between the vocal and nonvocal parts of the PLS for the two age groups was found to be .01 with use of a Fisher z transformation.

D. DISCUSSION

The Parsons Language Sample scores related to the Wechsler scores in a mixed fashion. The total scores and the WB verbal and PLS vocal scores show moderately high correlations. While they are significant, their absolute value is such that it cannot be said that the tests are entirely overlapping.

The combined correlation for total scores of .55 accounted for only 30 per cent of the variance; the combined correlation of .75 on the verbal and vocal scores accounted for 56 per cent of the variance. Thus, it is possible to say that while the verbal scale of the Wechsler and the vocal scale of the Parsons Language Sample, in part, were sampling similar behaviors, as the highest

correlating factors of the two tests, almost half of the variance was unaccounted for in their correlation. This suggests that for the population of this study, the Parsons Language Sample scores and the Wechsler scores are, in part, independent measures. Their usefulness as independent measures in terms of validating relationships must be determined in further studies.

More importantly, perhaps, the lack of correlation between the Wechsler performance-scale score and the Parsons Language Sample nonvocal score indicated an independent relationship which suggested that the measures were sampling different behaviors. Indeed, the lack of correlation between the two subscales of the Parsons Language Sample also suggested this. Anastasi (1) reports the Wechsler subscales correlate .60 to .83. In the present sample it was found that verbal and performance subscale scores of the Wechsler correlated .68 for the younger Ss and .79 for older Ss. These two correlations were found not to be significantly different from each other and yield a combined correlation of .74. This correlation was significant and well within the range of obtained correlations reported by Anastasi.

Thus, while it cannot be said that the behaviors sampled by the two subscales of the Wechsler were entirely independent, it does seem that the behaviors sampled by the two subscales in the Parsons Language Sample were relatively independent. Inasmuch as the PLS-NV score correlated neither with the PLS-V or WB-P scores, it may be that the behavior comprising the items of this scale gives a definition to the concept of language apart from the concept of intelligence. Perhaps, then, language as a concept independent of intelligence is best defined by nonvocal communicatory behaviors. Whether the concept will exhibit validity in terms of relationships with other variables must be the subject of further research.

It should be noted that the present study involved a population of mentally retarded Ss. The Parsons Language Sample has so far been used only with such Ss. The implications of the PLS-NV score as a measure of language apart from intelligence at this point are not assumed to hold for nonretarded Ss. This area, too, remains to be investigated.

E. SUMMARY

The present study investigated the relationships between scores on Wechsler intelligence tests and scores on the Parsons Language Sample test for 80 mentally retarded Ss. It was found that significant and moderately high correlations could be demonstrated between the Wechsler composite and Parsons Language Sample mean scores and between the Wechsler verbal and Parsons

Language Sample vocal scores. Nonsignificant correlations were obtained between Wechsler performance and Parsons Language Sample nonvocal scores. It was concluded that the Parsons Language Sample nonvocal score might prove useful as a measure of language which was relatively independent of the measure of intelligence.

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TRANSPPOSITION IN CHILDREN AS A FUNCTION OF AGE AND KNOWLEDGE*

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A. INTRODUCTION

The hypothesis that verbal mediation facilitates transposition of the middle-size relation in preschool children has been supported by experiments of Spiker and co-workers (3, 4). However, three studies by other investigators failed to find evidence of support (1, 2, 5). This investigator, attempting to test hypotheses about transposition, encountered difficulties suggesting a factor that may contribute to this conflicting evidence. The difficulties were with the range of knowledge within the several chronological-age years; no children could be found in some preschool years who met requirements for three levels of knowledge of the middle-size concept.

The earlier studies of middle-size transposition controlled age by selecting children from the approximate two-year-age span of 40 to 66 months. None studied the possibility that these two-age years might differ in the number of children available for the usual groups of verbal knowledge, nonverbal knowledge, and no knowledge of the concept. This study was planned to explore this possibility and to test a corollary hypothesis: if there is an age year in which children can be found easily at all levels of knowledge of the middle-size concept, in that age year verbal knowledge will facilitate transposition of the middle-size relation.

B. METHOD

1. *Subjects*

The subjects (Ss) were all children attending nine preschool centers² in Baltimore, Maryland, on scheduled test days. The age and sex distribution

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² The cooperation of the following preschool centers was helpful in this study: Brooklyn Community Nursery School, Cathedral Nursery-Kindergarten, Children's Nursery School, Clifton Day Nursery, Epsom Chapel Nursery School and Kindergarten, Govans Cooperative Nursery Center, Happy Acres School, Interdenominational Nursery School, and Salvation Army Nursery.

of the 359 children is shown in Table 1. There were 87 Ss at two day nurseries for lower-class families, 55 Ss at three schools serving lower-middle-class families, and 217 Ss at four schools for upper-middle-class families.

2. Procedures

Knowledge of the middle-size concept was tested by procedures developed by Spiker, Gerjuoy, and Shepard (4). Three black silhouettes of the same shape (square, triangle, or circle), but differing in area in the ratio of 4:2:1, were mounted on six cards shown in the same order to each child. The experimenter (*E*) said, while pointing, "This is big. This is small. What is this?" (middle-size). If *S* said nothing, *E* said, "Put your finger on the middle-sized one."

Responses were classified into three levels of knowledge. For the *verbal knowledge* level, the child answered the first question with "Middle-size," "Middle," or "Medium" on at least four of the six trials. For the *nonverbal knowledge* level, the child pointed correctly on at least four trials after the second question, or verbalized the concept on fewer than four trials. For the *no-knowledge* level, the child made no responses indicating knowledge of the concept.

The knowledge test was given five to 10 days before training. The child selected an inexpensive toy as reward after each test and training session.

The training session followed procedures described by Stevenson & Langford (6). Each child was given three gummed seals and told to stick them on the paper given him. Three white blocks were placed before him. Upper-block dimensions were 8×8 inches, 4×4 inches, and 2×2 inches, and all were $\frac{3}{4}$ inch thick. *E* said, "This is a game we play with blocks. See these blocks? I am going to hide a seal under one block, and I want you to see if you can find it." A screen was placed in front of the blocks, and the seal was hidden under the middle-sized block. *E* said, "Which block has the seal underneath?" When the child chose the middle-sized block, he was given the seal. When the child chose another block, *E* said, "No. This one has the seal," lifting the middle-sized block to show the child. When the seal was covered again, *E* proceeded to the next position. Block positions followed the same random sequence of 60 positions for all children. Training ended after the child made nine consecutive correct responses.

The test of transposition, given the next day, used the two smaller training blocks and the next step downward, a block of one square inch. Test trials were continued until four consecutive correct responses were made.

C. RESULTS

Evidence is shown in Table 1 that specific preschool-age years differ in the number of children at each of three levels of knowledge of the middlesized concept. The only age year in which many children were found at all three levels was the year from 54 through 65 months, or from 4-½ to 5-½ years. Few children below that age could verbalize the concept, while above that age, few children lacked knowledge of the concept.

TABLE 1
NUMBER OF 192 BOYS AND 167 GIRLS OF FOUR PRESCHOOL-AGE YEARS CLASSIFIED
AT THREE LEVELS OF KNOWLEDGE OF THE MIDDLESIZE CONCEPT

Age in months	Verbal knowledge		Nonverbal knowledge		No knowledge		Total
	Boys	Girls	Boys	Girls	Boys	Girls	
66-78 months	42	34	13	7	10	1	107
54-65 months	33	32	23	10	21	25	144
42-53 months	—	5	18	21	20	22	86
30-41 months	—	—	3	1	9	9	22
Total	75	71	57	39	60	57	359

Results of two χ^2 tests of independence of age and knowledge gave statistical support to the obvious relation between age and knowledge of the concept. The χ^2 testing the relative number of Ss in the two older-age years at each knowledge level was 19.763, significant at the .01 level (2 *df*). The χ^2 testing the proportion of Ss from each age year in the nonverbal knowledge and no-knowledge levels was 12.059, significant at the .01 level (3 *df*).

Transposition-test responses of children aged 4-½ to 5-½ years supported the hypothesis that verbal mediation will facilitate transposition of the middle-size response in the age year when children can be found easily at all levels of knowledge. A larger percentage of the children with verbal knowledge chose the middlesized block in the test than those with nonverbal or no knowledge, as is shown in Table 2. The *t* test of difference in proportions for these groups was 8.46, significant at the .01 level. Differences between nonverbal and no-knowledge groups were not significant.

Differences shown in Table 2 in the number of children from each age group choosing the middlesized block, disregarding knowledge, were significant at the .001 level in χ^2 tests of independence. The similar tests for knowledge groups, disregarding age, were significant at the .01 level.

The hypothesis was not supported by differences either in number of trials

to learn or in number of relearning trials after the test—two types of data often used as measures. No differences were obtained for either age or knowledge in analyses of variance of the logarithm $+1$ of the number of trials to learn, the transformation appropriate to the data. The mean number of trials was 16.4, while the median number was 13. The proportions relearning in four to five trials or in six or more trials differed by t test in accordance with knowledge when all ages were combined, but did not differ within the

TABLE 2
PERCENTAGE OF EACH AGE AND KNOWLEDGE GROUP CHOOSING THE
MIDDLESIZED BLOCK ON THE TRANSPOSITION TEST

Age in months	Verbal knowledge	Nonverbal knowledge	No knowledge	Total
66-78 months	63	60	27*	59
54-65 months	61	42	37	49
42-53 months	20*	41	31	35
30-41 months	—	25*	33	32

* Number of Ss too small to be reliable, as is shown in Table 1.

4- $\frac{1}{2}$ to 5- $\frac{1}{2}$ -year group. For all ages, 11 per cent of the verbal-knowledge group required six or more relearning trials, while 27 per cent of the nonverbal-knowledge group, and 31 per cent of the no-knowledge group required six or more relearning trials.

D. DISCUSSION AND SUMMARY

Tests of knowledge of the middlesize relation were given to 359 children, aged 30 to 78 months. Only one preschool-age year, that from 54 to 65 months, furnished subjects for each of the levels of knowledge needed to test the hypothesis that verbal mediation facilitates transposition of the middlesize relation. Test of transposition of this age group supported the hypothesis. These results suggest that the age range from 40 to 66 months used for subjects in other experiments provided inadequate control of the relation of age and knowledge and could account for the contradictory evidence obtained in these studies.

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SEX DIFFERENCES IN TAT AMBIGUITY, HOSTILITY, AND PROJECTION*¹

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A. INTRODUCTION

In an earlier article (3), the ambiguity value of each aspect of the TAT task was studied for a college population. The present study represents an examination of sex differences with regard to the task of constructing TAT stories. For our purposes, the essential tasks confronting the story teller are to tell *who* is in the picture in terms of (a) sex, (b) age, and (c) the relationship of any of the characters to each other, (d) *what* is going on, (e) *why* this is happening, and (f) *how* the story will end. By developing a scheme for classifying components of the story, the proportion of each different type of category can be tallied and a statistic can be used to describe the ambiguity represented in each of the aforementioned TAT tasks. Suppose, on TAT Card 13 MF, the who-relationship variable shows .40 of the stories dealing with a husband and his wife; .40, dealing with lovers; .10, with a prostitute and client; and .10, with a man who has murdered a woman. The statistic $\hat{H}$, a measure of uncertainty, describes the degree of uncertainty or the number of "bits" of information needed to place a response in a particular category. The higher the number of guesses, the greater the uncertainty and the greater the value of $\hat{H}$.

The formula for $\hat{H}$ is as follows:

$$\hat{H} = -\sum p(i) \log_2 p(i).$$

In the foregoing formula, p equals the proportion of cases in a particular category (i), which is then multiplied by its log to the base 2. The value attained for each proportion is summed over all proportions to yield $\hat{H}$, the unit of which is "bits." In the present example, the $\hat{H}$ value of 1.72 indicates the number of "bits" of information required to place a response in a particular category. The value of $\hat{H}$, however, is dependent upon the number of categories analyzed. With four categories, the maximum $\hat{H}$ value is 2.00, with each category having a proportion of .25 of the cases. It is necessary,

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therefore, to divide the obtained $\hat{H}$ value by $\hat{H}$ max to obtain the relative uncertainty value. In the present case, the relative uncertainty value is 86 per cent ($1.72 \div 2.00$). A more complete treatment of the measurement of ambiguity is given in earlier articles (2, 4).

The only hypothesis advanced is that, for each sex considered separately, each of the three *who* variables will show a significant negative correlation with the *what* variable. This hypothesis is predicated on the belief that a lack of ability to identify *who* is in the picture institutes a defensive set in *S* and, thereby, reduces the resulting variability of *what* is going on. Ease of identification, on the other hand, allows greater projection among *Ss* and, accordingly, results in greater variability (higher uncertainty) for the *what* variable for a population of *Ss*. No hypotheses are made for the variability of the *why* and *end* variables because it is believed they are relatively independent of *who* is in the picture.

B. METHOD AND RESULTS

The 31 TAT cards were randomly distributed into five sections of three to seven cards each and were given to several groups of introductory-psychology students at two northwestern colleges. The number of men supplying stories for any given card varies from 51 to 81; the number of women, from 51 to 90. The relative $\hat{H}$ percentages were computed for the *who* categories (sex, age, and relationship) and for the *what*, *why*, and *end* variables for each of the 31 TAT cards. The values, along with the mean value for each category, are shown in Table 1 (men) and Table 2 (women).

It is apparent that no significant difference exists between any of the means. Intersex correlations are as follows: sex, .87; age, .90; relationship, .65; what, .59; why, .62; and end, .84. Each correlation is significant beyond the .01 level.

As shown in Table 3 for men and in Table 4 for women, within each sex the six ambiguity variables were correlated with each other.

Two variables, hostility and projection, were added to the matrix to permit some determination of the extent to which the uncertainty values are correlated with the more-usual quantified scores. The TAT hostility scale—devised by Hafner and Kaplan (1) was a five-point scale; the projection scale was a three-point scale (with one point for the story that is little more than stimulus description, with two points for the average story, and with three points for the story above average in terms of richness of affect or introjection of personal material). All the variables in the matrix have been shown to have sufficient reliability for the purposes of the experiment (4).

Table 3 gives data that to some extent support the hypothesized negative relationship between the three *who* variables and the *what* variable. The *who* categories, however, are independent of the *end* variable, projection level, and extent of hostility expressed. Table 4 also shows significant support for the

TABLE 1
RELATIVE UNCERTAINTY PERCENTAGES FOR MEN

Card	Sex	Variable				
		Who Age	Relationship	What	Why	End
1	13.6	13.6		73.4	63.9	69.7
2	91.9	80.9	82.0	63.0	76.8	79.0
3BM	72.2	68.9		51.5	55.5	85.9
3GF	57.1	79.9		27.2	73.9	87.4
4	34.8	69.9	66.4	67.2	66.4	71.9
5	13.0	80.8		55.2	75.7	91.5
6BM	17.4	63.0	47.0	81.5	83.4	67.3
6GF	31.5	79.1	77.9	80.4	78.9	76.3
7BM	28.6	63.5	81.7	73.6	68.5	79.9
7GF	16.4	69.9	53.7	82.0	69.8	82.7
8BM	59.7	76.8	87.7	68.2	78.5	74.0
8GF	54.4	80.7		63.9	74.6	75.9
9BM	63.8	91.4	78.0	31.6	49.5	56.7
9GF	44.7	61.4	83.9	66.3	90.1	95.0
10	30.3	95.1	69.5	74.0	89.9	87.4
11	86.3			61.8	61.4	92.4
12BG	76.8			55.8	57.4	89.3
12F	49.8	59.8	82.1	71.5	74.0	79.0
12M	69.2	73.0	81.7	78.0	82.4	81.0
13B	00.0	13.0		58.3	71.2	88.5
13G	76.0	95.5		41.3	59.4	85.5
13MF	24.1	75.2	77.5	72.0	83.7	80.0
14	54.1	71.6		55.0	62.3	73.6
15	67.3	73.2		58.0	65.0	87.8
16	88.4			67.4	69.2	82.6
17BM	59.2	70.6		54.0	74.3	79.0
17GF	82.3	82.4	83.9	59.8	74.8	67.5
18BM	37.1	85.3		69.4	67.0	72.6
18GF	60.3	87.3	82.4	69.7	70.6	73.3
19	88.0			70.8	65.6	82.9
20	22.3	84.6		51.7	68.2	81.0
Mean	50.7	72.1	75.7	63.0	71.0	79.9
SD	25.7	19.5	11.7	12.8	9.7	8.5

hypothesized negative intercorrelation between the *what* and the *who* variables.

The patterns of correlation for both sexes seem relatively similar, with the exception of the significant correlations between sex and hostility and age and hostility, indicating that uncertainty as to the sex and age of the character is associated with a lack of hostile projection. Apparently women like to know *who* is in the picture before they express hostile feeling.

Table 5 provides a comparison of the means and standard deviations for the *who* variables (sex, age, and relationship) and for the *what*, *why*, and *end* variables for male Ss. Table 6 shows the same comparisons for female Ss. Both tables show that the *who* variable, sex, is significantly less uncertain

TABLE 2
RELATIVE UNCERTAINTY PERCENTAGES FOR WOMEN

Card	Sex	Variable				
		Who Age	Relationship	What	Why	End
1	10.6	10.6				
2	74.9	86.3	84.8	66.8	62.8	78.6
3BM	68.3	79.8		59.4	78.7	87.3
3GF	52.9	64.7		37.1	70.3	77.5
4	34.8	72.2	66.4	43.1	47.8	78.9
5	22.8	73.7		70.5	86.8	70.8
6BM	19.8	59.9		69.4	64.8	80.4
6GF	9.4	81.1	52.0	84.0	82.0	90.4
7BM	32.0	72.7	76.4	66.4	78.4	76.2
7GF	27.6	84.6	57.0	66.8	71.3	75.6
8BM	53.7	77.4	71.4	78.4	74.5	79.4
8GF	70.6	77.8	86.1	77.8	77.3	76.4
9BM	49.1	85.6		88.4	73.3	73.0
9GF	79.8	68.6	78.8	26.8	36.5	34.5
10	14.2	93.9	79.7	65.0	86.5	74.8
11	86.9		55.0	71.4	84.0	80.7
12BG	83.6			58.3	61.3	94.2
12F	48.9	61.2		33.6	57.6	71.6
12M	78.1	77.3	82.7	75.5	81.0	82.9
13B	00.0	19.4	88.5	62.7	72.6	71.5
13G	92.7	89.5		94.8	69.5	83.9
13MF	23.7	56.0		71.5	66.5	80.9
14	99.9	77.7	62.3	72.0	73.4	59.8
15	71.3	83.4		63.8	67.4	86.5
16	78.5			63.1	73.0	92.6
17BM	44.3	81.3		52.4	64.8	85.3
17GF	81.2	82.2		55.1	79.7	74.7
18BM	44.0	72.5	86.8	54.5	70.8	78.1
18GF	66.1	89.5		87.0	70.5	71.5
19	92.6		79.9	72.5	78.4	86.2
20	32.8	74.8		71.3	66.3	79.2
Mean	53.1	72.4		49.8	71.5	62.9
SD	28.9	18.9	73.9	64.8	70.9	77.3
			12.4	15.7	10.6	11.0

than any other variable for both men and women. For both men and women, the *end* variable is significantly more uncertain than the *what* and *why* variables. For men only (Table 5), the *what* variable is significantly less uncertain than the *who* variables age and relationship and the *why* variable. Women show similar trends.

Sex differences on projection and hostility are given in Tables 7 and 8.

TABLE 3
THE INTERCORRELATIONS (FOR MEN) OF THE WHO SEX VARIABLE, THE WHO AGE VARIABLE, THE WHO RELATIONSHIP VARIABLE, AND THE WHAT, WHY, END, HOSTILITY, AND PROJECTION VARIABLES^a

Variable	Sex	Who Age	Relationship	What	Why	End	Hostility	Projection
Who (age)	.49**							
Who (relationship)	.38**	.19						
What	-.30*	-.25	-.37**					
Why	-.31	.02	-.00	.50**				
End	.05	-.07	.13	-.08	.07			
Hostility	-.19	.04	.01	.29	.39*	.03		
Projection	-.00	-.27	-.15	.37*	.30	.25	.52**	

^a The intercorrelation of each of the three *who* variables with the *what* variable was tested via a one-tailed *t* test. All other comparisons are two-tailed.

* Significant at the .05 level.

** Significant at the .01 level.

TABLE 4
THE INTERCORRELATION (FOR WOMEN) OF THE WHO SEX VARIABLE, THE WHO AGE VARIABLE, THE WHO RELATIONSHIP VARIABLE AND THE WHAT, WHY, END, HOSTILITY, AND PROJECTION VARIABLES^a

Variable	Sex	Who		What	Why	End	Hostility	Projection
		Age	Relationship					
Who (age)	.50**							
Who (relationship)	.78**	.25						
What	-.34*	-.31*	-.37**					
Why	-.19	.11	-.19	.57**				
End	.17	-.08	-.08	.37*	.38*			
Hostility	-.41*	-.39*	-.10	.23	.45**	.33		
Projection	.06	-.08	-.28	.15	.38*	.47**	.31	

^a The intercorrelation of each of the three *who* variables with the *what* variable was tested via a one-tailed *t* test. All other comparisons are two-tailed.

* Significant at the .05 level.

** Significant at the .01 level.

In Table 7 all six significant t values show women projecting more than men. In Table 8, of the five significant t values, three show women manifesting more hostility than men; two, men more than women. When the responses of both sexes are correlated, using the 31 TAT cards for both projection

TABLE 5
MEANS, STANDARD DEVIATIONS, AND t VALUES (FOR MEN) BETWEEN THE WHO SEX VARIABLE, THE WHO AGE VARIABLE, THE WHO RELATIONSHIP VARIABLE, AND THE WHAT, WHY, AND END VARIABLES

Parameter and variable	Sex	Who Age	Who Relationship	What	Why	End
Mean	50.7	72.1	75.7	63.0	71.0	79.9
SD	25.7	19.5	11.7	12.8	9.7	8.5
Who (age)	3.54**					
Who (relationship)	4.52**	.75				
What	2.38**	2.07*	3.24**			
Why	4.07**	.26	1.44	2.79**		
End	5.99**	1.93	1.38	6.12**	3.85**	

* Significant at the .05 level.

** Significant at the .01 level.

TABLE 6
MEANS, STANDARD DEVIATIONS, AND t VALUES (FOR WOMEN) BETWEEN THE WHO SEX VARIABLE, THE WHO AGE VARIABLE, THE WHO RELATIONSHIP VARIABLE, AND THE WHAT, WHY, AND END VARIABLES

Parameter and variable	Sex	Who Age	Who Relationship	What	Why	End
Mean	53.1	72.4	73.9	64.8	70.9	77.3
SD	28.9	18.9	12.4	15.7	10.6	11.0
Who (age)	3.06**					
Who (relationship)	3.43**	.27				
What	1.99	1.67	1.96			
Why	3.24**	.36	1.23	1.79		
End	4.38**	1.18	1.36	3.63**	2.33*	

* Significant at the .05 level.

** Significant at the .01 level.

and hostility, values of .65 and .99 are obtained. No significant sex difference is found when the cards are divided into the following classifications: no persons, single person, multiple persons, males only, females only, and both sexes.

C. DISCUSSION

The data show little difference between men and women in their thematic stories. No significant difference is found for the uncertainty variables nor for difference in projection and hostility (when the cards are classified

according to the number and sex of the characters depicted). Perhaps the only clear difference lies in the fact that, on six of the 31 cards, women project richer stories than do men. Examination of these cards does not reveal a clear explanation for this finding. It is not due to similarity of sex

TABLE 7
PROJECTION ON EACH TAT CARD FOR EACH SEX

Card	N	Male		N	Female		t
		Mean	SD		Mean	SD	
1	51	1.94	0.68	68	1.89	0.73	0.33
2	76	1.92	0.68	61	1.97	0.66	0.44
3BM	52	1.96	0.74	68	1.97	0.69	0.07
3GF	56	1.94	0.75	67	2.01	0.66	0.66
4	51	2.09	0.63	68	2.10	0.71	0.04
5	56	1.66	0.60	54	1.53	0.88	0.87
6BM	77	2.10	0.59	87	2.26	0.67	1.51
6GF	75	1.88	0.61	81	2.12	0.63	2.45*
7BM	51	1.74	0.69	69	1.77	0.73	0.17
7GF	56	1.82	0.68	67	1.91	0.60	0.77
8BM	75	1.85	0.65	61	2.00	0.66	1.30
8GF	56	1.80	0.54	52	1.88	0.68	0.66
9BM	52	1.22	0.46	69	1.33	0.53	1.13
9GF	56	1.71	0.64	53	1.98	0.63	2.29*
10	56	1.37	1.19	67	1.94	1.08	2.82**
11	54	1.40	0.60	51	1.58	0.70	1.42
12BG	75	1.84	0.62	61	1.72	0.70	1.12
12F	51	1.90	0.65	68	1.69	0.62	1.70
12M	75	1.90	0.70	61	1.78	0.59	1.07
13B	56	1.57	0.63	66	1.76	0.60	1.68
13G	55	1.34	0.60	67	1.73	0.67	3.35**
13MF	56	2.10	0.76	68	2.03	0.67	0.61
14	74	1.86	0.76	61	1.77	0.64	0.79
15	52	1.90	0.78	69	1.73	0.70	1.22
16	81	1.82	0.76	90	1.70	0.74	1.12
17BM	56	1.53	0.63	54	1.70	0.74	1.28
17GF	56	1.76	0.66	54	1.81	0.66	0.36
18BM	56	1.60	0.61	68	1.87	0.67	2.26*
18GF	75	2.06	0.61	60	2.05	0.69	0.14
19	73	1.76	0.77	58	1.84	0.72	0.59
20	56	1.53	0.63	54	1.90	0.70	2.95**

* Significant at the .05 level.

** Significant at the .01 level.

between picture and S, for the six cards depict two cards with women only, two cards with men only, and two cards with both sexes represented. There is, however (for these six cards), a nonsignificant trend to be less uncertain for women than for the remainder of the cards; but two of the cards, 9 GF and 13 G, are glaring exceptions. Regardless of the causes, this finding is in keeping with earlier evidence that college women do tend to involve themselves more fully in experimental tasks than do men (3). Whether this state

exists because of the alleged greater social sensitivity of women or is due to the fact that most experimenters have been men is a phenomenon that awaits further study.

The data, also, offer no support for the belief that similarity of *S* and the

TABLE 8
HOSTILITY ON EACH TAT CARD FOR EACH SEX

Card	N	Male Mean	SD	N	Female Mean	SD	t
1	51	1.19	1.04	68	0.83	0.97	1.93
2	76	0.72	0.97	61	0.83	0.91	0.71
3BM	52	1.61	1.12	68	1.88	1.09	1.33
3GF	56	1.87	1.32	67	1.91	1.24	0.15
4	51	1.60	1.20	68	1.94	1.16	1.51
5	56	0.57	0.90	54	0.87	1.00	1.63
6BM	77	1.89	1.06	87	1.52	1.11	2.21*
6GF	75	1.26	1.33	81	1.64	1.34	1.78
7BM	51	1.03	1.31	69	.98	1.18	0.23
7GF	56	0.80	.94	67	.92	.96	0.72
8BM	75	2.34	1.11	61	1.92	1.21	2.17*
8GF	56	0.37	.97	52	.30	.96	0.40
9BM	52	0.34	.79	69	.23	.62	0.88
9GF	56	1.23	1.17	53	1.13	1.30	0.42
10	56	0.85	1.18	67	1.02	1.20	0.79
11	54	0.87	1.14	51	1.19	1.34	1.33
12BG	75	0.48	1.06	61	0.37	0.97	0.59
12F	51	0.86	1.19	68	0.91	1.21	0.22
12M	75	1.73	1.31	61	2.06	1.06	1.62
13B	56	0.50	0.79	66	0.87	1.07	2.18*
13G	55	0.58	1.27	67	0.65	1.18	0.34
13MF	56	2.19	1.62	68	2.92	1.25	2.82**
14	74	0.79	1.27	61	0.52	1.16	1.30
15	52	1.80	1.19	69	2.13	1.20	1.47
16	81	0.65	1.26	90	0.30	0.66	2.36*
17BM	56	0.53	0.99	54	0.83	1.25	1.39
17GF	56	1.00	1.51	54	1.11	1.43	0.39
18BM	56	2.23	1.38	68	2.60	1.14	1.64
18GF	56	2.74	1.21	60	2.73	0.86	0.09
19	73	0.86	1.22	58	0.81	1.16	0.25
20	56	1.01	1.30	54	0.88	1.16	0.55

* Significant at the .05 level.

** Significant at the .01 level.

character depicted in the card furthers projection. As has been expounded elsewhere in greater detail (3), the crucial factor is the cultural or personal value attached to the sex or occupation depicted rather than mere physical similarity.

The support for the hypothesis that each of the three *who* variables is negatively correlated with the *what* variable negates the belief that the ambiguity of the characters facilitates the ease of tapping the private world

of the individual when variability of *what* is told is used as an index of projection. It should be emphasized, however, that this finding in no way denies the possibility that projection level is furthered by the ambiguity of other aspects of the picture than identification of the characters. Ambiguity as to *what* is occurring, for example, shows a positive relationship to projection (.15 for women and .37 for men). The second of the two foregoing correlations reaches significance at the .05 level. Perhaps our task for the future is to create pictures such that identifying the characters is not difficult, thereby furthering interest and involvement; but then making the actions of the characters vague to further projection.

D. SUMMARY AND CONCLUSION

Men and women from introductory-psychology classes received a selection of three to seven screen-projected TAT cards in response to which they wrote stories. A sufficient number of Ss were employed, so that at least 50 Ss of each sex were represented for each card. The stories were classified according to *who* was in the picture (sex, age, and relationship), *what* was happening, *why*, and the *end* of the story. The probability of a particular kind of occurrence within each variable was measured by $\hat{H}$, a measure of relative uncertainty. Other variables studied were projection and hostility.

It was hypothesized that each of the three *who* variables (sex, age, and relationship) would show a negative correlation with the *what* variable and this hypothesis was substantiated. In general, few sex differences were found except that women projected significantly richer stories than men to six of the 31 cards. This finding was not attributable to the similarity of story teller and stimulus character.

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LUNAR AND SEASONAL VARIATIONS IN OBSTETRIC FACTORS*

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A. INTRODUCTION

The relationship of lunar phases, seasons, temperature variations and other climatic factors to obstetrics (including the incidence of various complications) has been the focus of considerable recent research. The relation of the full moon to birth rates has been the primary concern of many studies because superstition has persisted that the incidence of delivery is significantly increased during this phase of the moon.

A review of the available studies, however, reveals equivocal findings. Gunther (4) has concluded that the incidence of delivery is greatest seven to nine days after the full or new moon. Schnurman (17) reports that the largest number of births occurs on or within 24 hours of a change in the phases, with a tendency for the first quarter to be the predominant phase. On the other hand, neither Hosemann (5, 6) nor Rippmann (16) find any significant relationship between birth patterns and lunar phases.

Investigators have also assessed the relations of factors, such as seasons, to birth rates. Several studies have established significant seasonal variations in birth rates, particularly among white populations. Points (15), as well as Pasamanick, Dinitz, and Knobloch (11), finds a birth trough in the spring months March to May with a peak in the late summer months August to September. The relation of seasons to birth rates among Negro samples, however, and to birth weights among either white or Negro populations has not been as well explicated.

Related studies have assessed the "effects" of seasons on obstetric complications. For example, Pintner and Forlano (13, 14) have demonstrated that persons born during the winter months generally obtain lower IQs than those born in the summer months. Knobloch and Pasamanick (7) have reported higher admission rates to Columbus State School (for mental defectives) from children of winter birth than for children of summer birth. In addition, Pasamanick and Knobloch (10) also report a reliable relationship between

* Received in the Editorial Office on August 15, 1964. Copyright, 1966, by The Journal Press.

the winter months (January to March) and two complications: pre-eclampsia or eclampsia and uterine bleeding; while Kovar and Taylor (8) report higher abortion rates in various months (January, April, September, and December) related to marked temperature changes. Monthly and seasonal variations in other obstetric complications, such as prematurity, have not been consistently explored.

The purposes of this study were to explore further the relationships of various climatic factors to obstetrics: specifically (a) to secure further evidence concerning the relations (if any) between birth rates and the phases of the moon, (b) to evaluate seasonal variations in prematurity, and (c) to present normative data by sex for a southern Negro population in regard to mean birth weights and monthly birth rates.

B. MATERIAL

Data for this study consisted of 1907 Negro deliveries (which occurred during the years 1957-1962 inclusive) at the McLeod Infirmary, Florence, South Carolina, a 235-bed community-type private hospital. These deliveries were used because of the availability of the records and because only rarely were any of the deliveries accomplished with medical induction. By far the majority of the mothers were indigents, many presenting themselves at the hospital initially at the time of delivery. The records of all Negro deliveries during the years studied were reviewed and those involving Caesarean section or pitocin-induced births were excluded. This left only full-term, spontaneous deliveries for study. Ages of the mothers ranged from 13 to 35, while gravidity varied from first pregnancies to gravida 15.

The time span used for determination of total births for each lunar phase consisted of the two days preceding the calendar day through the day following the calendar day denoting each phase. For example, if a full moon fell on June 15, the dates June 13 through June 16 were used in determining total births for the full-moon phase. This period was chosen to take into consideration variations in the time interval between new moon, quarters, and full moon, and the manifestation of the maximum effect of the lunar phases on earth (gravitational pull). This time interval varies considerably from place to place and may range from one hour to a day or more (3).

C. RESULTS AND DISCUSSION

The major results of this study are summarized in Tables 1 and 2. Table 1 shows total births (without regard to sex) for each of the various phases of

the moon. The number of births considered is 1045, as 862 of the births did not fall within the designated periods. The data show that, for each of the six years, more births generally occurred during the full moon and the new moon—with the fewest births occurring during the first quarter. Chi-square analysis of the data (following a combination of the totals into full-moon and new-moon phases and first-quarter and last-quarter phases) shows that significantly more births occur during the new-moon and full-moon phases than during the first-quarter and last-quarter phases ($X^2 = 4.82$, $df = 1$,

TABLE 1
TOTAL BIRTHS BY PHASES OF MOON FOR 74 CONSECUTIVE LUNAR CYCLES*

Year	New moon	First quarter	Full moon	Last quarter
1957	41	25	38	36
1958	38	31	49	45
1959	50	44	39	41
1960	64	44	41	45
1961	46	45	58	50
1962	43	44	51	37
Total	282	233	276	254

* $X^2 = 4.82$, $p < .05$.

$p < .05$). The most logical "explanation" of this finding is the effects of gravitational pull on the uterus and uterine membranes.

An "explanation" might be that, at the full-moon phase and last-quarter phase, the gravitational forces of sun and moon are directed at right angles to each other in their pull on the earth. At new moon and full moon, the gravitational force of the moon is exerted along nearly the same line of action as that of the sun, and the two gravitational pulls tend to reinforce each other and produce a greater influence. Date of conception, obviously, is an important determiner of date of birth. Also, in Southern-Negro culture, degree of belief in the influence of the moon conceivably could have some relation to date of birth.

Table 2 gives monthly totals for births, birth rates, prematurity rates, and mean birth weights by sex. For both sexes, the table shows marked monthly variations in total births. More meaningful, however, are the monthly birth rates (following correction for discrepancies in month sizes). Analysis of these data yields significant monthly variations for the females ($X^2 = 23.25$, $df = 11$, $p < .02$). Peaks in August, February, September, and December, as well as low birth rates in March and May, largely contribute to the significant difference. While similar analysis of male births fails to yield reliable differences ($X^2 = 11.74$), the monthly birth patterns for

TABLE 2
MONTHLY TOTAL BIRTHS, BIRTH RATES, PREMATURITY RATES, AND MEAN BIRTH WEIGHTS BY SEX

Month	Males				Females			
	Monthly total births	Birth rates	Prematurity rates	Mean birth weights	Monthly total births	Birth rates	Prematurity rates	Mean birth weights
January	80	8.18	12.50	113.84	82	8.46	9.76	108.79
February	80	8.99	6.25	110.30	85	9.65	12.94	108.14
March	90	9.20	6.66	109.18	63	6.51	15.87	108.51
April	68	7.19	10.29	109.38	78	8.31	3.85	110.10
May	67	6.84	8.96	107.60	59	6.08	13.56	106.75
June	88	9.30	6.82	111.17	78	8.31	11.54	107.60
July	72	7.36	8.33	110.90	74	7.64	12.68	105.97
August	91	9.30	12.09	109.32	103	10.63	12.16	106.47
September	92	9.71	3.26	114.99	88	9.39	11.36	107.13
October	74	7.57	9.46	106.52	82	8.46	8.54	111.63
November	73	7.72	9.59	115.27	67	7.14	7.46	106.67
December	84	8.59	16.67	108.07	91	9.39	9.89	106.44
Total	959	100.00	9.19	110.61	950	100.00	10.74	107.84

the two sexes are similar, with a peak observed for males in August and lowest rates in May. Above-average birth rates for males occur in September and June, and April and July are the lowest birth-rate months.

These results for Negro births are consistent in general with previous findings for white births (15). Pasamanick, Dinitz, and Knobloch (12) attribute the August-September peak (found more frequently in states with temperate climates) to increased sexual activity during the cold winter months. These investigators further suggest high summer temperatures and humidity, as well as increased fetal deaths (presumably resulting from protein deficiencies and heat stress), as responsible for the spring decline in births. Analysis of our data by seasons yields significant results for the females ($\chi^2 = 9.84$, $p < .02$). The large decrease in births during the spring (March, April, May) and the relative increase during the winter months (December, January, February) are largely responsible for this finding. Similar analysis for male births reveals nothing of significance ($\chi^2 = 1.59$).

Table 2 reveals a tendency toward higher prematurity rates for females (10.74 per cent to 9.19 per cent), a difference that is attributable primarily to the larger mean male birth weights. The combined prematurity rate of 9.95 per cent compares favorably with Dunham's previous finding of 9.7 per cent for a comparable sample of Negro infants (1). There are marked monthly variations in prematurity rates for both sexes—the highest prematurity rates for males occurring in January, April, August, and December; while for females, highest prematurity rates are found in March, May, and February. These monthly variations, however, apparently do not represent a consistent pattern; i.e., statistical analysis of prematurity rates by season reveals no reliable differences for either sex. It is interesting that the monthly prematurity variations are dissimilar for the two sexes. For example, three times as many male premature births as female premature births occur in April; whereas approximately two and one-half times as many female premature births as male premature births occur in March. While the meaning of these findings is not clear, the peak months for male premature births parallels Kovar and Taylor's results (8) concerning monthly incidence of spontaneous abortions (January, April, September, and October). In addition, Edwards (2) reports a significant increase of anencephaly and congenital dislocation of the hips in January births.

Table 2 shows that the mean male birth weights are larger than those for females, a reliable sex difference ($t = 3.41$, $p < .01$) that has been found repeatedly among white births. This discrepancy is consistent for all months except April and October, for which months a reversal in favor of

higher mean female birth weights is noted. Analysis of birth weights by season reveals larger birth weights for males during the fall months September, October, and November than during the spring months March, April, and May ($t = 2.01$, $p < .01$), with no reliable seasonal differences for the females. These relationships are maintained even after deletion of all premature births. Pasamanick, Dinitz, and Knobloch's explanation for the spring decline in births (11) seems equally plausible in accounting for the present lower mean male spring birth weights. That is, protein deficiencies and heat stress resulting from high summer temperatures and humidity might adversely affect mean birth weights. However, since all mothers were subjected presumably to the same summer temperatures and humidity, one might also expect lower mean female spring birth weights, an expectation that our data do not confirm.

An interesting phenomenon is the generally greater monthly variability in male birth weights. McDonald, Gynther, and Christakos (9) have found a disproportionate number of male births among a group of single white primigravidas experiencing a variety of obstetric complications. Similarly, Tricomi, Serr, and Solish (18) have found a male-female ratio of 160.2:100 in the sex-chromatin mass of fetuses not reaching viability. Collectively, these findings seem to imply that male and female conceptions react differentially to intrauterine environment (perhaps as a function of climatic conditions) to produce a greater male wastage, more obstetric complications connected with male births, and greater variations in mean monthly birth weights.

D. SUMMARY

This study was designed to assess lunar and seasonal variations in obstetric factors such as birth rates, birth weights, and incidence of prematurity. Subjects for the study were 1909 full-term Negro deliveries occurring over a six-year period at a southern community hospital. Births via Caesarean section or induction were excluded. Significant findings were as follows: (a) more births occur during the new-moon and full-moon phases than during the quarter phases; (b) monthly variations are observed in female birth rates, highest rates occurring in August and September; (c) there is a spring birth trough (March, April, May) for female births; (d) mean male birth weights are reliably larger than mean female birth weights; and (e) mean male birth weights for fall months (September, October, November) are larger than those for spring months (March, April, May). These findings are discussed and related to previous results.

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CONTENDING HYPOTHESES OF ONTOGENESIS FOR
THE EXUBERANCE-RESTRAINT PERSONALITY
FACTOR, U. I. 21*¹

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A. IMPORTANCE OF THE U. I. 21 BEHAVIOR PATTERN

The last decade has witnessed a marked shift in research strategy in the multivariate approach to personality. Despite the initial plethora of ill-defined and unreplicated factors, a number of systematic workers using more painstaking and technical methods have firmly cross-validated a series of personality source traits over three domains of measurement (questionnaire, life ratings, and objective tests—now designated Q, L, and T data). Paralleling the progress in stable factor definition and cross-media equivalency matching, a number of psychologically penetrating analyses have emerged to enrich our understanding of the genetic and situational components contributing to the ontogenetic molding of isolated factors. Cattell and Scheier's discussion of the anxiety factor (8, 10), Eysenck's work on ergic regression or neuroticism (16), and Cattell's analyses of U. I. 28—Super Ego Asthenia *vs.* Rough Assurance, the "authoritarian" personality factor (7)—illustrate this trend.

The exuberance-restraint source trait, designated Universal Index 21 (or simply U. I. 21) in the Compendium series, has held a subtle but important position in the history of personality theory. The recent addition of information through three new studies makes it timely to reconsider in more exact terms the theories of its origin.

A pattern of the kind under consideration has been "spotted" at the prefactorial or (largely) literary and clinical level for a long time and has undoubtedly at times been confused with extraversion—introversion. To make a brief digression into these earlier sightings of the dimension we should probably begin with Theophrastus and continue through the literary characterologists. However, as often happens, an unsuspected appendage has been added by the purely literary discussions of U. I. 21: namely, the association

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of youthfulness and naivete with Exuberance (as illustrated by literary characters such as Don Quixote, Falstaff, and Tom Sawyer and epitomized in the phrase "youthful confidence, exuberance, and impetuosity") and the linkage of pessimism and depression with Restraint (illustrated by literary characters such as Hamlet, Prufrock, and the Protagonist in *Notes from the Underground*). Incidentally, it was this "deception by titles" that led Cattell to introduce the factor-indexing systems U. I. one to 36 in T data and A to Q₄ in L data. In modern parlance we might say that a *confounding* has occurred among the semantic associations of U. I. 21 in contrast with a purely scientific description of the source trait. Although, as we shall see, this prescientific intuition may have been a precursor of the earlier first-order factor interpreted as energetic decisiveness (3) and the second-order contribution of U. I. 21 to emotional ardor.

An important outcome of the multivariate approach to personality is the stripping away of literary appendages and allusions and the revealing of a meaningful dimension of description in sharp relief. The purpose of the present paper is to explicate U. I. 21; to demonstrate its relationship to physiologic, state, and other personality factors; and to suggest several hypotheses for the developmental pattern of exuberance—restraint.

B. PRINCIPLES AND METHODOLOGY OF SOURCE-TRAIT INTERPRETATION

A general set of principles is rapidly evolving for the formulation of hypotheses interpreting factors and for an iterative cycle of hypothetico-deductive experiment in testing these hypotheses. A core of principles applicable to recognizing and interpreting factors at the initial statistical level has been set forth by Cattell (7). To extend these principles into further experimental possibilities one must:

1. Examine the "goodness," in terms of the hyperplane count and statistical significance, of the simple structure deduced by "blind" independent rotation in several related studies. The 16 studies listed in Table 1 were "blind" and independent and reached hyperplane counts averaging 59 or 60 per cent.
2. Check the significance of matching the agreement of the independently achieved factor patterns across studies by employing the Cattell *s* index or other factor-matching coefficients.
3. Consider hypotheses, first, as suggested by the loading pattern itself: i.e., as suggested by the nature of the variables that have (a) high positive loadings, (b) high negative loadings, and (c) zero or near-zero loadings, though included in the studies.
4. Analyze extension variables and their factor pattern, a pattern that

serves as a powerful adjunct to the factor-interpretation problem. Variables that are correlated with the included variables are as crucial as the variables included in the factorization.

5. Determine the rank order of general variance of the factor among factors and whether or not it is also found (with or without modification) at other ages and in other populations.

6. Inspect the correlations of the factor with questionnaire (Q) or life-rating (L) factors.

7. Examine the nature-nurture ratios between families and within families. (It would be fruitless to devote much time to a temperamental theory if this initial "sorting" points to an environmental explanation or to go far with learning theories if the evidence points clearly to an hereditary explanation.)

8. Examine age trends in the factor score.

9. Look at the second-order structure among objective-test factors in which the given factor might be involved.

10. Look for evidence of state factors (P- or Incremental R- technique) akin to the trait in pattern.

11. Examine correlations with (or group differences on) particular life criteria: e.g., school success, clinical problems, and delinquency.

12. Seek evidence of effects of manipulative experiments upon factor scores (i.e., applications to experimental contexts).

13. Study closely in a clinical sense the behavior of *individuals* known to be extremely high or low on the factor measurement.

C. NATURE OF THE FACTOR PATTERN

U. I. 21 has been identified in 12 independent, blindly rotated factor analyses with adults and four factor analyses with children. Earlier approximations to the factor pattern have been discussed by Cattell (5) and center about the conception of mental power (output over time) as "some kind of energy and impetuosity present in people," who succeed not academically but "in a life of action"—a la Churchill² or John Paul Jones—"more than others of the same intelligence level" (5, p. 248). With the variability that typically exists among different rotations of the same factor the only convincing picture of the loading pattern for most people is that obtained by averaging across several studies. In this case we are able to present in Table 1 an averaging across one to eight of the 16 independent

² The verve of U. I. 21(+) reminds the writer of Lady Asquith's memorial to the late Sir Winston Churchill: "Endowed by nature with a double dose of vitality and enthusiasm."

TABLE 1
SALIENT TEST MARKER FOR U. I. 21: EXUBERANCE *vs.* RESTRAINT

Test title	Compendium designation	Number of studies	Average loading*
Crime and Punishment: faster speed of judgment	MI 289 (T97)	1	+.63
Hard-Headed Decisiveness: faster speed of judgment	MI 244 (T361)	4	+.60
Reading Tempo and Memory for Interesting Material: faster tempo	MI 278 (T6)	1	+.59
Reading Speed Under Frustration: faster rate of reading (delayed feedback)	MI 511 (T299)	1	+.59
Reading Speed Under Frustration: faster rate of reading to oneself	MI 516 (T299)	1	+.59
Criticalness of Evaluation: faster speed of judgment	MI 288 (T8)	2	+.58
Metabolic Rate: greater increase in basal metabolic rate after stimulation	MI 75 (T209)	1	+.56
Drawings (Unstructured): higher absolute number of aggressive implements perceived	MI 425 (T20)	1	+.52
Letter and Number Comparison: faster speed (numbers)	MI 308 (T44)	3	+.48
Hidden Pictures: fewer hidden objects correctly seen	MI 170 (T33)	1	+.47
Line-Length Judgment: faster speed	MI 309 (T45)	2	+.45
Letter and Number Comparison: faster speed (letters)	MI 307a (T44)	3	+.41
Reading Speed Under Frustration: higher sound pressure (loudness of voice) (normal conditions)	MI 513a (T299)	1	+.41
Voice Amplitude: higher amplitude	MI 513b (T109)	1	+.41
Achievement Satisfaction: more masculinity of interests	MI 63 (T271)	1	+.40
Heartogram: greater increase in heart rate after startle	MI 84a (T314)	3	+.40
Pulse Rate Under Shock: greater increase with stress	MI 84b (T108)	3	+.40
Myokinesis: larger myokinetic movements under threat relative to size of movements under normal conditions	MI 95 (T124)	2	+.40
Fluency (Verbal, Personal, Dreams): higher total verbal fluency on topics	MI 271 (T43)	7	+.35
Reading Tempo and Memory for Interesting Material: better recall of emotionally interesting relative to dry material	MI 87 (T6)	1	+.34
Metabolic Rate: higher basal metabolic rate	MI 74 (T209)	3	+.33
Shape Comparison: more errors	MI 350 (T185)	1	+.32
Hand Tremor: greater average amplitude	MI 466a (T106)	2	+.32

TABLE 1 (continued)

Test title	Compendium designation	Number of studies	Average loading*
Hand Tremor: higher frequency of tremor	MI 466b (T106)	2	+.32
Bodily Dimensions: less weight	MI 506 (T257)	1	+.31
Voice Pitch: higher pitch	MI 76 (T198)	1	+.30
Animal Sounds: Readiness to Imitate: more animal sounds imitated	MI 347 (T132)	1	+.30
Bodily Dimensions: narrower shoulder width	MI 576 (T257)	1	+.30
Opinion Inventory Y: less willingness to change attitude after receiving additional information	MI 34 (T10)	7	+.30
Disturbing Pictures: more attention to disturbing relative to non-disturbing pictures	MI 428b (T296)	2	+.26
Social Judgment Speed (Child): faster speed of social judgment	MI 168a (T360)	2	+.25
Moral Expediency: faster speed of socioemotional judgment	MI 168b (T58)	2	+.25
Bodily Dimensions: shorter length and girth of muscles (less mesomorphy)	MI 486 (T257)	2	+.25
Opinion Inventory X: better immediate memory	MI 167a (T9)	7	+.24
Memory for Names and Objects: higher total score	MI 167b (T118)	7	+.24
Jokes (Amount of Laughter): less overt laughter	MI 157 (T141)	2	+.24
Numerical Ability: higher score	MI 199 (T35)	8	+.23
Opinion Inventory Y: less suggestibility to authority	MI 35 (T10)	7	+.23
Blood Pressure: higher systolic blood pressure	MI 444 (T304)	2	+.21
Mind Wandering: less mind wandering <i>vs.</i> ability to do problems in one's head	MI 476 (T365)	2	+.21
Pupil Dilation After Startle: less dilation after startle	MI 445 (T241)	2	+.21
Opinion Inventory X: greater tendency to agree	MI 152 (T9)	8	+.20
Psychogalvanic Reflex: smaller amount of conditioning (lower amplitude of conditioned G.S.R.)	MI 469 (T128)	2	+.20

* Tests reflected to positive pole for ease of interpretation.

studies, these 16 studies having been separately set forth in a detailed summary of test loadings by Hundleby, Pawlik, and Cattell (18). This averaging of loadings over several studies has the decided advantage of casting the U. I. 21 source trait into sharp relief. Table 1 presents a description of the objective test markers for U. I. 21, along with M. I. (Master Index) and T (test) code numbers in the Compendium series (12), the number of studies in which it appeared, and finally the average factor loading across studies. For ease of interpretation, the Exuberant pole is labelled U. I. 21 (+); while the Restraint pole is labelled U. I. 21 (—). Although the major interpretation of the Exuberance-Restraint factor centers about those variables having average absolute factor loadings of .20 and higher, ancillary findings will clarify the picture. Before attempting to distil what is common to all variables with loadings (i.e., the essence of the source trait), it is helpful to group the variables under 10 descriptive categories as follows:

1. *Speed of Social Judgment*

Earlier descriptions of U. I. 21(+) emphasize speed of social judgment. U. I. 21(+) is associated with making more rapid decisions in the hard-headed realism items (M. I. 244), social judgment (M. I. 168a), criminal punishment (M. I. 289), and evaluation of the performances of others (M. I. 288). This cluster of findings suggests that U. I. 21(+) may have either what the French designate as *coup d'oeil*—a capacity to take in essentials rapidly or to be prone to rapid, inconsiderate, and possibly tactless judgments. Hundleby, Pawlik, and Cattell (18) have hypothesized that there is an element of lack of concern for and involvement with social pressures and problems.

2. *Speed of Perceptual Judgment*

In the perceptual domain, U. I. 21(+) is characterized by faster speed of perceptual judgment in comparing numbers (M. I. 308), faster speed of line judgment—regardless of accuracy—(M. I. 309), and faster speed of letter comparison (M. I. 307). Although these are relatively simple tasks, there is the suggestion that U. I. 21(+) has an "openness" with respect to input-output systems.

3. *Faster Tempo*

Related to the foregoing, U. I. 21(+) shows faster tempo of tapping (M. I. 268) and faster reading tempo (M. I. 278). This indicates an habitually fast mode of reaction: motor responsiveness.

4. *Verbal Fluency*

A salient characteristic of U. I. 21(+) is higher verbal fluency on varied topics (M. I. 271). There is strong indication that this facet of performance involves not only speed of motoric expression, which is certainly involved, but also ideational fluency (11). Supportive evidence in terms of perceptual and ideational richness comes from a variety of measures, including more hidden objects correctly seen in pictures (M. I. 170), greater number of objects seen in unstructured pictures (M. I. 282), and more perceptions of aggressive implements (M. I. 425). However, the finding of little accuracy in perceptual closure (M. I. 146b) and less ability to suggest classifications (M. I. 37) perhaps indicates a high fluency and productiveness not checked by critical tendencies. Fifteen years ago, Cattell noted that this factor takes most of the variance from Spearman's fluency factor and suggested that fluency be considered a personality factor rather than an ability (2).

5. *General Competence*

Although general competence is a vague term, U. I. 21(+) involves a lot of capacities—memory, fluency, quickness of decision—that, though distinct in our factoring from intelligence, would popularly simulate it. These "abilities" include better immediate memory (M. I. 167a), better memory for names (M. I. 249), higher numerical ability (M. I. 199), higher ability to do problems in one's head (M. I. 476), higher total number correct in letter exercise (M. I. 1735), and less initial difficulty in readaptation (M. I. 1736).

6. *Errors in Perceptual Tasks*

That U. I. 21(+) at times involves speed at the price of accuracy is indicated by many errors in shape comparisons (M. I. 350) and little accuracy in perceptual closure (M. I. 146b). On the other hand, with reaction time there are fewer errors under complex instructions (M. I. 71); and there is an absence of any significant loadings on error variables, such as the number of slanting lines crossed, Cursive Miniature Situations (M. I. 16a).

7. *Imperviousness To Social Suggestion*

The relative imperviousness of U. I. 21(+) to social suggestion is exemplified by little change of opinion or attitude in the various "shift" measures: less suggestibility to authority (M. I. 35), less shifting of attitudes away from those of neurotics (M. I. 194), and less shift of attitude toward

successful people (M. I. 193a). Fewer overt facial reactions to jokes (M. I. 157) may also, in a different context, be an expression of the same self-assured tendency.

8. *Low Self-Estimation*

After considering the foregoing fluency and speed of judgment, which might seem to imply high dominance or at least irrepressibility, it is surprising to find that the pattern includes a number of tests that show a generally low estimate of one's own capabilities. Not only is a low estimate given of prowess in *past* activities, but this is carried forward into the future; thus we find less self-confidence regarding untried performance (M. I. 108), lower level of estimate of experience and accomplishment (M. I. 147b), less excess aspiration over performance (M. I. 101a, b), more long-term life goals (M. I. 458), less considered possible for self (M. I. 192), and lower estimation of personal prowess (M. I. 104). Support for this appears also in young children, with less belief in attainability of goals (M. I. 212).

9. *Sensitivity to Threat and Emotional Stimulation*

In general, shock and stress lead to a marked decrement of performance on a variety of simple tasks. This group of variables contains more decrease in myokinesis under threat (M. I. 95), more effect of restraint upon performance (M. I. 93), more slowing of reaction time due to shock (M. I. 456), and more impairment of performance by fright (M. I. 46a, b). There is no clear evidence on the relative effects of praise and punishment. A physiological reaction accompanying that of overt behavior in the stress situation is suggested by more increase of pulse rate under stress (M. I. 84b) and more metabolic-rate change with stimulation (M. I. 75). (The loading for less pupil dilation with stress (M. I. 445) is surprising when we consider antagonistic parasympathetic action.) Additional confirmation for the implication that U. I. 21(+) is associated with a general interest in and capacity to react to emotional stimulation comes from more attention to disturbing *vs.* nondisturbing pictures (M. I. 428b), better recall of emotionally interesting material relative to that of dry material (M. I. 87), better recall of frightening than of nonfrightening filmstrip material (M. I. 459), and higher absolute number of aggressive implements perceived (M. I. 425). A low and inconsistent loading appears for the proportion of threatening objects seen in drawings (M. I. 105).

10. *Physiological Activity*

In general, physiological measures present a pattern of high activity. Among such variables are higher magnitude of mean PGR deflection to

threatening stimuli (M. I. 43), higher basal-metabolic rate (M. I. 74), and higher systolic blood pressure (M. I. 444). Also involved in U. I. 21(+) are less involuntary muscle tension (M. I. 78), less PGR conditioning (M. I. 469), more static ataxia, and smaller area under pulse-wave EKG (M. I. 491). Possibly also related to these measures and indicating an erratic level of performance is more oscillation (variability) in performance (M. I. 13).

11. *Slight Body-Build*

It is perhaps consistent with evidence discussed later of relatively strong constitutional determination of this factor that significant and appreciable body-build association has been found with it. Body-build measures, mainly from Wells' extension analysis (25), but also partly from the Cattell and Scheier factor analysis (9), indicate that the U. I. 21(+) individual tends to be lower on mesomorphy (M. I. 486) and to have lower physical weight (M. I. 506), smaller shoulder width (M. I. 576), and lower score on a muscular-development index.

D. EXPERIMENTAL, QUESTIONNAIRE, HIGHER-ORDER, AND CRITERION ASSOCIATIONS

Section C gives the most concentrated account we can provide of the nature of the U. I. 21 source trait in terms of the variables that are influenced by it or associated with it to a significant degree. Interpretation, however, as pointed out, must be aided by experimental evidence "outside" the factor.

1. *Questionnaire Correlates*

Relationships between the 16 P. F. and U. I. 21(+) were obtained in studies by Cattell (4), Scheier and Cattell (24), and Cattell and Scheier (9). These findings support the finding that F(+), Surgency (enthusiastic, talkative) is positively though not highly related to this factor (see 5). Additional 16 P. F. factors that demonstrate some potential as correlates are M(+), Autia (Bohemian, unconcerned); O(-), Confidence (confident, unshakable), and Q₄(+), High Ergic Tension (tense, excitable). The directions [except perhaps for O(-)] are those expected from the nature of U. I. 21, but the loadings are low and no corresponding second-order questionnaire factor is known.

On the MMPI, Knapp's research (19, 20) gives low negative correlation with the Lie Scale ($r = -.24$) and Dominance ($r = +.23$); while, on the Guilford-Zimmerman scales, General Activity and Ascendancy agree in correlation in both Knapp's submarine and helicopter groups (+.22, +.32 and +.11 and +.30 respectively). Certainly, surgency, autia, dominance,

general activity, and drive tension aptly describe verbally what is seen in the objective tests.

All evidence points to the lack of any significant relationship between U. I. 21(+) and questionnaire and self-report measures of anxiety.

2. State-Factor Matches

No factor from analyses of psychological states, through the use of P-technique or incremental R-technique, has been discovered in the variables found with loadings on U. I. 21. This fact implies that we are dealing purely with a trait and with a consistent one.

3. Loadings on Second-Order Objective-Test Factors

U. I. 21 appears to have loadings on only one second-order factor, F(T) III(+), Temperamental Ardor *vs.* Temperamental Apathy, in which it has the highest average loading (13). This second-order factor is difficult to interpret, but it contains first-order factors with relatively high hereditary determination and has a central character of "willful exuberance and ardor of temper" which is congruent with U. I. 21(+). When a primary factor has high loadings on a second-order factor or a variable has high loadings on a primary factor the possibility must always be considered that it is the factor or, in some sense, the generator or core of the factor. The quality of U. I. 21 is central to the factors that the second-order structure U. I. (T) III brings together.

4. Criterion Correlations

Criterion information comes from a number of sources, and each will be discussed separately.

a. *Clinical criteria.* Comparisons of groups of normals and neurotics indicate that U. I. 21(+) has definite value in the prediction of neurosis. Scheier, Cattell, White, and Swenson [see Cattell and Scheier (10)], using estimated factor scores based on previously established marker variables, found a significant difference ($p < .01$) between normal persons and clinically diagnosed neurotics. Consistent with this lower U. I. 21 score of neurotics are the low nonsignificant negative correlations found by Cattell and Scheier (8) between U. I. 21(+) and psychiatrists' ratings of *overall* anxiety and *bound* anxiety. Recent but unpublished research on the diagnostic value of the O-A Test Battery has indicated a salient difference ($t = 6.07$, $p < .001$) between 138 mental patients and 96 nonpatient controls on U. I. 21 in favor of greater exuberance (U. I. 21+) among the nonpatients.

b. *School and academic achievement.* The relationship between exuberance—restraint and academic and school achievement was investigated by Scheier

and Cattell (24); and, by Pawlik (22), with undergraduates and 11-year-old children. In both studies low negative correlations were found.

c. Military criteria. The predictive value of U. I. 21 in a military context has been investigated—in the Sells study—by Cattell (4). With four criteria of pilot training and a future prognosis, U. I. 21 showed a consistent positive, but nonsignificant correlation (14). Knapp (19, 20) found a nonsignificant relationship with Final Flying Grades, but a significant negative correlation with AGT, a measure of general ability. This finding is congruent with our general competence in fluency and memory domains. Knapp has reported significant positive correlation (+.27) between U. I. 21(+) and class standing among Naval Submarine School candidates.

d. Nature-nurture results. Only one investigation (13) concerns genetic and environmental contributions to U. I. 21; and this was by a first trial of the Multiple Abstract Variance Analysis method (6) which, as Loehlin (21) has pointed out, tended to underestimate the true contribution from heredity. This evidence placed U. I. 21 about third highest in rank order among 12 personality factors with the highest hereditary determination. The figures indicate about 50-50 hereditary-environmental determination within the family but, for the reasons that Loehlin gives, an educated guess would be that hereditary influence predominates.

e. Age trends. The evidence is clear that over the middle-childhood range U. I. 21(+) declines steadily with age.

E. NEUROHUMORAL HYPOTHESES OF THE ORIGINS OF THE U. I. 21 PATTERN

Three theories have been put forward by Cattell (5), Cattell and Scheier (10), and others to explain the phenomena of the U. I. 21 pattern. These theories are that U. I. 21 (*a*) is an axis of lack of inhibition *vs.* inhibition; (*b*) represents some hypothalamic, sympathetic-system neural facilitation; and (*c*) represents the influence of some cortical chemical pacemaker.

Theories that U. I. 21 is a form of low rigidity, important in creativity, have also been put forward by Getzels and Jackson (17) by implication, since some of the creativity measures developed by Getzels and Jackson come from this factor. This fourth "theory," however, is merely descriptive and, as Cattell has pointed out, rigidity—flexibility is no longer tenable as a unitary concept as it is a surface trait with contributions from at least four personality factors: U. I. 16 (Developed Ego *vs.* Unassertiveness), U. I. 23 (Mobilization *vs.* Regression), U. I. 26 (Self-Realization *vs.* Homespunness), and U. I. 33 (Reactive Dismay *vs.* Sanguine Poise).

The theory that U. I. 21 best be viewed from its negative end as a form

of inhibition or restraint encounters the difficulty that we can recognize, thanks to the strategy of broad factoring of the personality sphere, at least two other factors with inhibition or restraint. The first factor is U. I. 17 (Timid Distrust *vs.* Trustingness), with its clear character of general inhibition, which is believed to be a function of general timidity of disposition. The second factor is extraversion—introversion, U. I. 32, which has been considered by Eysenck to be reactive inhibition; but, by Cattell, an experience of inhibition restricted to social stimuli. If we distinguish (a) experience of inhibition, (b) proneness to inhibition (timidity, U. I. 17), and (c) natural resistance to inhibition [see Cattell (2)] these concepts might leave room for U. I. 21 to be considered as natural resistance to inhibition—otherwise unaccounted for in observed general patterns.

This theory of "uninhibitableness" may be contrasted with the alternative theories that consider the individual differences to be due to differences in energy. The two hypotheses in the "energy" category may be distinguished as (a) the cortical-chemical pacemaker or strong-cup-of-coffee theory that a person high in U. I. 21 has a raised metabolic rate throughout the cortex and (b) the sympathetic-responsiveness theory that requires (in some way not physiologically clear or anatomically locatable) the U. I. 21 person to be more endowed in whatever neurohormonal structure produces more energizing in terms of those emotional responses associated with the sympathetic system.

Cattell has urged these two theories (particularly the second) as worthy of extensive experimental effort because, in the first place, some kind of neurohormonal course is indicated by (a) the large hereditary component and body-build association; (b) the substantial relations to autonomic, metabolic, and other physiological responses shown; and in its area of action (5, p. 248), (c) a certain parallelism with that found in three factors: U. I. 1, general intelligence; U. I. 16, ego assertiveness; and U. I. 22, cortertia. These factors are known to have considerable physiological determination (23).

The cortical-pacemaker theory requires that U. I. 21 show a significant relation to alpha-rhythm rate and other EEG signs. Such associations have been shown for U. I. 16 and U. I. 22 (23), justifying the theory that cortertia is in fact identical with what, in the arousal field, has been called activation level (or, at least, the first of two or more major distinct factors in activation level). Unfortunately, workers in the EEG field have not given a trial to this hypothesis. However, because cortertia, U. I. 22, is easily distinguishable from U. I. 21 as *generalized* speed and activity beginning at the simplest levels (reaction time) and U. I. 21 involves fluency, good mem-

ory, and speed of decision only (i.e., activity at the higher cognitive levels), it seems unlikely that a chemical pacemaker would affect only the latter speeds and not the basic reflex speeds. Of course, we may find metabolic pacemakers of different kinds localized in action but, initially, U. I. 22 seems a better expression of a general rise in activation level through a neurohumoral level.

For the foregoing reason, and because of the association of U. I. 21 with fairly general personality characteristics connected with emotional expression (self-confidence, surgency, freedom from neurosis), Cattell (10) has favored the second neurological theory: namely, that U. I. 21 is determined by endowment in some hypothalamic-sympathetic structure favoring high emotional energy (i.e., favoring spontaneous reactivity—not just a high activation level from external stimulation). This theory, which should be associated also with the maintenance of many reverberatory circuits, would explain the high fluency of association, rapid perception, and rapid judgment along with the autonomic-activity indications. It would not be incompatible with that presumably neurohumoral decline in general emotional activity with age, a decline in which U. I. 21 clearly participates.

The striking association ($p < .001$) or low U. I. 21 with neuroticism (10) has been explained by Cattell in terms of U. I. 21 affecting neuroticism—not vice versa (though the alternate possibility is admitted). Cattell argues that the high fluency of U. I. 21 favors a high resourcefulness of mental trial-and-error examination of possible solutions for frustrating situations by means of which the total, nervous-favoring frustration level is reduced. This view is supported by the significant associations of U. I. 21 with occupational success and creativity. The fact that the only obtained experimental relation to school achievement is negative does not contradict the foregoing assumption because scholastic achievement in existing examinations is largely intertwined with stereotyped responses.

In view of the comparative lack of EEG and neurohumoral research on the behavior pattern under discussion, Cattell has not felt it desirable to go beyond the descriptive label "exuberance" for U. I. 21; but exuberance connotes this hypothesis of a neurohumoral root and implies many experimental checks. Differences in U. I. 21 should correlate with EEG phenomena but of a different kind than those found associated with U. I. 16 and U. I. 22. Differences in U. I. 21 should change systematically over age, downward from the age range previously observed. They should correlate with the protein-metabolism process connected with memorizing, and so on. Meanwhile, at the overt behavioral level, more investigation is needed on the emotional

richness of response [i.e., on what Burt (1) has designated as a pattern of sthenic emotionality rather than frustrated general emotionality]. For example, this hypothesis suggests that a low U. I. 21 score should be significantly associated with simple schizophrenia.

F. THE INHIBITABILITY HYPOTHESIS OF U. I. 21

In contrast to the main theory, which is essentially one of energy (or, at most, of a natural resistance to inhibition), one may make a case for an environmental-learning theory in terms of the level of inhibition acquired. In this theory, however, one would have to consider U. I. 17, Lack of Inhibition *vs.* Timidity, and U. I. 32, *Exvia vs. Invia*.

The dimension that Eysenck (16) has hypothesized in psychiatric terms as hysteria *vs.* dysthymia can be better accounted for in a precise factor-analytic technique as the notion given by an insufficiently extracted and roughly rotated composite of U. I. 17 and the extraversion-introversion factor, U. I. 32. Cattell (5) interprets U. I. 17 as a clear-cut general-inhibition dimension defined by indices such as cautious closure, absence of unapproved reading tastes, delayed judgment in dark-adaptation perception, slowing of reaction time in complex situations, refusal to believe in suggested current (i.e., suggested by a nonexistent electric shock), low inaccuracy, and slow speed of judgment. The temporal pattern of U. I. 17 indicates a rapid increase from 9 to 14 years (in contrast to the steady decline over middle childhood, of U. I. 21). A nature-nurture analysis implies a substantial hereditary determination, and Cattell has hypothesized a constitutional cortical capacity to inhibit (proneness to inhibit), partially based on hypothalamic reactivity to threat (i.e., timidity of disposition) and opposed to impulsiveness and to the tendency to dissociate easily unpleasant or threatening memories.

The second factor that must be differentiated from the U. I. 21 (—) is the introversion pole of U. I. 32. Historically there have been countless theories about extraversion—introversion; but most have been nonoperational and, in any case, put forward before the precise identification of the core factor *Exvia vs. Invia* in the vague cluster of the alleged qualities involved. Eysenck has associated U. I. 32 with greater reactive inhibition in conditioning and the tendency to dissipate reactive inhibition very slowly. Cattell's own hypothesis on the essence of the second-order factor is at once more comprehensive and restricted. Speed and strength of reactive inhibition (to certain classes of stimuli), once admitted to be a component of U. I. 32, is regarded essentially as a pattern of inhibition in the social world only. If we look at the separate factors in the second-order factor domain we see

that the sizothyme (*vs.* affectothyme) individual is more at home with inner symbols; the desurgent, more discouraged from experiences of reacting outwardly; the threctic, more easily inhibited; and the autious personality, constitutionally addicted to giving greater importance to inner stimuli. The only formula that seems to cover all facets is a dual one: greater inhibition of external reactivity by social stimuli (in terms, mainly, of past discouragement and present timidity) and consequent greater attention by reason of "intensity" (displaced interest) of felt immediate "importance" of inner stimuli and ideas. In the ratio of internal to external reactivity that characterizes U. I. 32, the *experience of inhibition* is an important element.

The proposed concept of *natural resistance to inhibition* introduced by Cattell (2) counters the foregoing concept. The basic notion proposed for study is that individuals differ in initial resistance to inhibition and, further, that this *inhibitibility* tendency rests on a neurohumoral substrate. Aside from respecting constitutional factors in the ontogenesis of U. I. 21, it allows for a theoretical account that leaves the door open for learning experiences (through socialization channels) that modify the basic pattern of behavior. It is anticipated that future investigations at the nursery-school level, as well as genetic studies at that and earlier age levels, will shed light on these contending hypotheses.

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RELATIONSHIP BETWEEN PERCEIVED CHILD-REARING PRACTICES AND VERBAL AND MATHEMATICAL ABILITY*

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A. INTRODUCTION

Several studies (1, 2, 3) have reported a close correspondence between child-rearing practices and intellectual growth. Levy (6) has observed that the "overprotected" child does well in reading but relatively poorly in arithmetic. Kent and Davis (5) have suggested that a demanding discipline is a cause of the superior development of verbal abilities. Bing (3) has found that a close relationship with a demanding and intrusive mother facilitates the development of high verbal abilities, whereas a casual relationship enhances the development of nonverbal abilities.

So far, most studies have emphasized the parent's perception of his own child-rearing practices rather than the child's perception of them. The purpose of the present study is to determine the relationship between male and female college students' retrospective perception of their paternal and maternal child-rearing practices and their own verbal and mathematical ability.

B. METHOD

1. *Subjects*

The Ss were 104 male and 100 female freshman and sophomore students attending Catholic colleges located in the Boston area. All the Ss were white, American-born Catholics, and were predominantly from middle-class Irish and Italian ethnic-background families with both parents alive and living together.

2. *Test Instrument*

The 130-item Parent-Child Questionnaire was used as a measure of the S's perception of his parents' child-rearing practices. Ten scales representing different aspects of such behavior are available. However, since Roe and Siegelman (7) have demonstrated that the scales can be represented by three

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factors—a loving-rejecting factor, a casual-demanding factor, and an overt-attention factor—factor scores rather than raw scores have been used as estimates of parental behavior.

3. Procedure

Ss were tested in groups ranging from two to 60 students. A biographical-information data sheet related to family history was first presented to the Ss, and then the mother and father forms of the Parent-Child Questionnaire were administered. The Ss were encouraged to be frank and honest in their responses, and no name appeared on the answer sheet. The verbal and mathematical scores on the Scholastic Aptitude Test were secured from college-admission records and were precoded on the answer sheets prior to the testing session.

C. RESULTS AND DISCUSSION

For each of the two forms of the Parent-Child Questionnaire (mother and father), the 10 scores were intercorrelated, and the resulting matrix was submitted to a principal-components factor analysis with Verimax rotation (4). Because the three factors extracted had loading similar to those observed by Roe and Siegelman (7), the names suggested by those authors have been retained.

Table 1 shows the Pearson correlations between the Verbal and Mathematical Scholastic-Aptitude Test scores and child-rearing-practices factor scores of both the father and mother forms of the Parent-Child Questionnaire. The significant negative relationship ($p < .05$) for the male group indicates

TABLE 1
CORRELATION BETWEEN PARENT-CHILD QUESTIONNAIRE FACTOR SCORES
(MOTHER AND FATHER FORMS) AND SCHOLASTIC APTITUDE TEST
SCORES FOR MALE AND FEMALE Ss

Parent-Child Questionnaire factors	Scholastic Aptitude Test			
	Male		Female	
	Verbal	Mathematics	Verbal	Mathematics
<i>Father form</i>				
Loving-rejecting	-.22*	.02	-.05	-.06
Casual-demanding	.19	.09	.10	.16
Overt-attention	-.29**	-.07	-.14	-.13
<i>Mother form</i>				
Loving-rejecting	-.20*	.12	-.09	-.05
Casual-demanding	.14	.15	.04	.12
Overt-attention	-.06	.00	-.11	.01

* $p < .05$.

** $p < .01$.

that the greater one's verbal ability the less loving and the less attentive was the father and the less loving was the mother, as perceived by the *S*. Although a similar trend is apparent for the female group, the relationship is not significant beyond chance expectancy. Despite the fact that previous emphasis has been on the mother's role, it seems that the father's behavior may have an important influence on the verbal skills of his sons.

Contrary to the suggestions by Levy (6) that high verbal ability is fostered by overly attentive and overly loving parents, our findings emphasize the negative influence of parental behavior.

The differences between Levy's findings and ours may be due in part to the identity of the rater (parent or the child), the type of behavior items rated, and the nature of the sample selected for study. Levy (6) asked parents how they viewed their behavior. We asked students to describe their parents' behavior. Because the two viewpoints concerned may be unrelated (8), neither estimate by itself is adequate. Factors such as selective perception and motivated forgetting could bias the parent's rating as well as the child's rating of the behavior.

The Parent-Child Questionnaire, by including a variety of behavior items, reflects a more representative and general estimate of parental behavior than that obtained by Levy, who considered a limited number of extreme child-rearing practices. Factors such as the greater homogeneity of the present sample than the previous sample with reference to age, education, religion, and ethnic background (as well as the difference in the ages of the *Ss* studied and the difference in time when the studies were completed—1933 and 1964) could also be important contributors to the contradictory outcomes.

The insignificant correlations between mathematical scores and child-rearing-practice factor scores for both the male and female *Ss* indicate that a variety of conditions (besides parental influence) contributes to performance on mathematical-aptitude tests. Environmental effects, such as the type of mathematical training, the extent of practice on similar mathematical tests (as well as the general ability of the *Ss*), could be important determiners of mathematical scores.

D. SUMMARY

To determine the relationship between perceived child-rearing practices and verbal and mathematical ability, 104 male and 100 female college students were asked to take the Parent-Child Questionnaire. The significant coefficients found indicate that males with less-loving and less-attentive fathers and less-loving mothers tend to have higher verbal ability than do other males. No

relationship, however, was found (for either sex) between mathematical ability and perceived parental behavior.

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SOME EARLY BEHAVIORAL EFFECTS OF WHOLE-BODY EXPOSURE TO X-RAYS*¹

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A. PROBLEM

Several studies with rhesus monkeys have demonstrated the behavioral effects of both acute and chronic exposures to X-ray radiation (1, 2, 3). Assay of effects usually has begun some hours after exposure and continued over a matter of days or weeks following acute exposure or between successive chronic exposures.

By way of contrast, the purpose of the present studies is to measure possible behavioral effects during the first hour after exposure. The studies were based on adolescent rhesus monkeys of both sexes.

B. METHODS

1. *Subjects*

Forty rhesus monkeys, ranging in age from approximately 3½ to 4 years, served as Ss. Seven of the Ss were assigned to the control group; seven to a 400r group; 10 to a 500r group; nine to a 600r group; four to a 700r group; and three to an 800r group. The assignment of differing numbers of Ss to the different dosage groups was not a matter of choice, but was dictated by the fact that this study was but a portion of a larger study. The formal training histories of the Ss were virtually identical and included only the tasks used in the present study.

2. *Radiation Procedures*

The X-ray exposure utilized a Van de Graff accelerator with a one-eighth-inch-thick lead target backed by one-eighth inch of water and one-eighth inch of brass sheet to filter out soft radiation. The beam had a half-value thickness of 12 millimeters of lead. The dose rate varied from 11.4r to 12.6r per minute, with a nominal rate of 12r per minute. The dose variation was

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¹ This work was conducted at The Radiobiological Laboratory of The University of Texas and The United States Air Force and was supported (in part) by Contract AF 41(609)-2005 and The School of Aerospace Medicine.

—.08 over the extremities of the *S* which was rotated at two rpm and located approximately 2.5 meters from the target.

3. *Test Procedures*

One of the studies was based on systematic observations of the free-cage behavior of the *Ss*. During each observation the *S* was placed in a special holding cage. This cage ($3' \times 3' \times 3'$) was constructed of steel bars placed three inches apart (center to center). A wooden cage bed was affixed to one side of the cage.

To record an observation the observer sat eight feet from the special holding cage and recorded on a mimeographed category sheet (every 10 seconds on the 10-second mark) the nature and direction or nondirection of the *S*'s behavior. Each observation lasted five minutes; so the total frequency count for each *S* for each observation was 30.

The behavioral categories on the mimeographed category sheet included (a) nondirected visual activity; (b) nondirected locomotor activity; (c) manual, oral, and visual response to the *S*'s body parts; (d) manual, oral, and visual response to the cage parts as manipulanda; (e) visual response to the experimenter; and (f) orientational response to noises occurring outside the testroom. The dependent variable of paramount concern was nondirected locomotor activity.

Each *S* was observed once prior to exposure and again once during the first hour after exposure or, as was the case with the control *Ss*, after sham exposure.

A second study was based on the minimum response latencies of the *Ss*. To achieve pre-exposure matching, the study was based on five of the 0r *Ss*, six of the 400r *Ss*, eight of the 500r *Ss*, and eight of the 600r *Ss*.

The testing was done in a modified version of the Wisconsin General Test Apparatus (WGTA), with the animal-carrying cage serving as the holding cage during testing. The spatial separation between the two food wells on the test tray was 12 inches. A square, orange-painted, wooden block served as the test object.

All *Ss* had been given extensive preliminary training before the present study was initiated. During the present study each *S* was tested for 12 trials prior to exposure and for 12 trials during the first hour after exposure or sham exposure.

During each 12-trial test run the *S* was tested on response latency to the food-rewarded object block placed randomly over either of the two food-well positions. On each trial a clock was activated when the forward opaque

screen was raised. The clock stopped when the *S* pushed the wooden block from a food well.

The dependent variable was the *S*'s minimum response latency in milliseconds during each 12-trial test run.

The third study involved the discrimination of a white card holding a centered black dot (one sixty-fourth inch in diameter) from a blank white card. The testing was done in a modified version of the WGTA, and the *Ss* had received extensive training before the present experiment started.

Each *S* was given 24 test trials prior to exposure and 24 test trials during the first hour after exposure or sham exposure. If *S* failed to respond within one minute on any trial, testing was terminated. The proportion of *Ss* failing to respond after exposure precluded an analysis of the error data; therefore, the data were analyzed in terms of the numbers of *Ss* in the various groups refusing to respond after radiation exposure. Balkers versus workers were compared across the controls and 400r *Ss* as Group 1, the 500r and 600r *Ss* as Group 2, and the 700r and 800r *Ss* as Group 3.

C. RESULTS

Figure 1 shows the mean nondirected locomotor activities before and after exposure time for the *Ss* of each of the six groups. The difference between groups is significant beyond the .001 level, a time effect is significant beyond the .001 level, and a groups-by-time interaction effect is significant beyond the .025 level. The orthogonal comparison between the control and 400r *Ss* grouped as one set and the remaining *Ss* grouped as a second set yields effects significant beyond the .001 level. In other words, the data show a depression in locomotor activity accruing to radiation exposure and indicate that the threshold to profound depression lies between 400r and 500r.

Figure 2 shows the mean minimum response latency for the *Ss* before and after exposure. The difference between groups is significant beyond the .05 level, a time effect is significant beyond the .001 level, and a groups-by-time interaction effect is significant beyond the .025 level. The orthogonal comparison between the control and 400r *Ss* grouped as one set and the 500r and 600r *Ss* grouped as another set yields a group-by-time interaction effect significant beyond the .005 level. The data show an increase in minimum response latency accruing to radiation exposure and indicate, as did the foregoing study, that the threshold to profound effect lies between 400r and 500r.

Figure 3 shows the proportion of *Ss* of each group that balked on the dot-discrimination problem. As stated earlier, Group 1 contained the control and 400r *Ss*; Group 2, the 500r and 600r *Ss*; and Group 3, the 700r and 800r *Ss*.

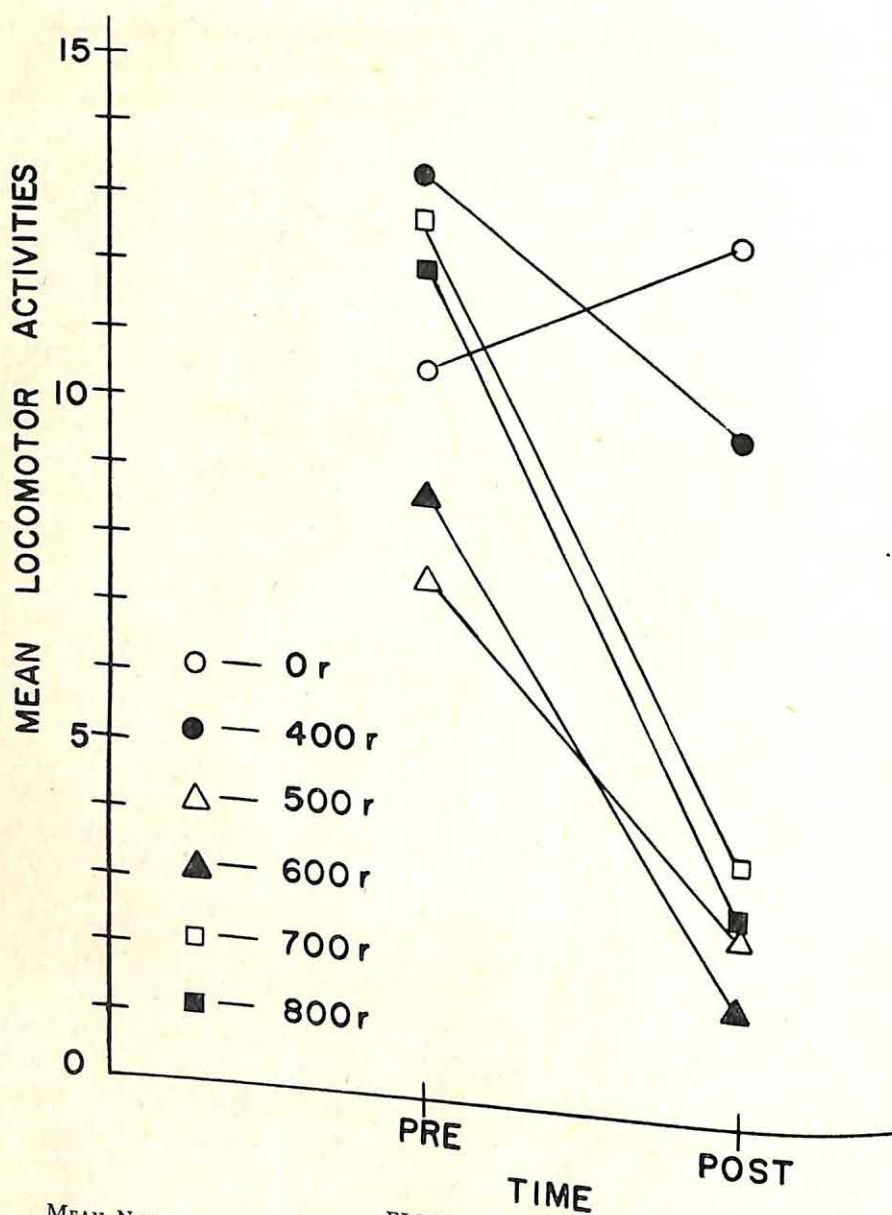


FIGURE 1
MEAN NONDIRECTED LOCOMOTOR ACTIVITIES BEFORE AND AFTER EXPOSURE TIME
FOR THE Ss OF EACH OF THE SIX GROUPS

Chi-square analysis of the data yields a difference between proportions of balkers in the three groups significant beyond the .01 level. In other words, the higher the relative radiation dosage, the greater is the proportion of Ss that balk on the problem.

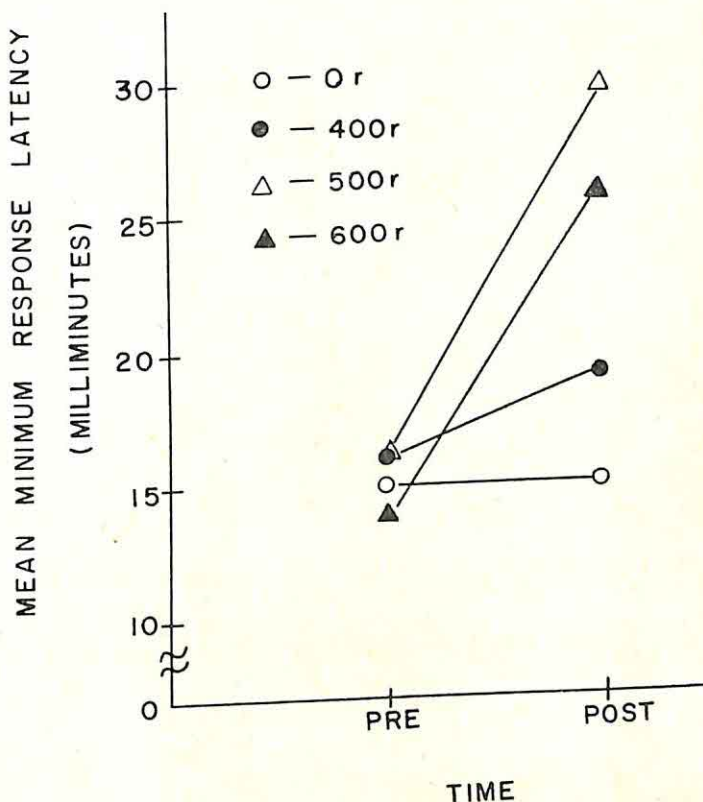


FIGURE 2
THE MEAN MINIMUM RESPONSE LATENCY BEFORE AND AFTER EXPOSURE TIME
FOR THE Ss OF EACH OF THE FOUR GROUPS

D. DISCUSSION

The results of the present studies show decreased locomotor activity, increased minimum response latencies, and decreased motivation to respond on a dot-discrimination problem during the first hour after exposure to X-ray

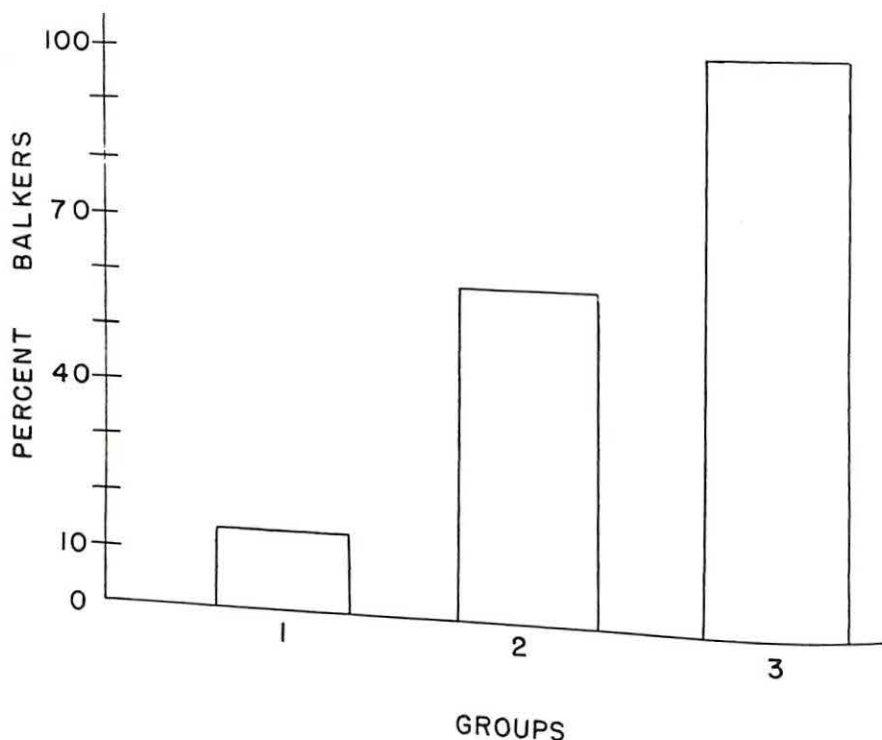


FIGURE 3
THE PROPORTION OF *Ss* OF EACH OF THE THREE GROUPS THAT BALKED
ON THE DOT-DISCRIMINATION PROBLEM AFTER EXPOSURE TIME

radiation. In addition, they indicate that the threshold to pronounced effect lies between 400r and 500r.

The specific results are possibly of little significance other than as indicators that exposure renders the animals sick. The indication, however, of a threshold to such sickness falling between 400r and 500r should be of importance to anyone involved in radiation research or in the treatment of radiation sickness.

E. SUMMARY

Adolescent rhesus monkeys were studied before and during the first hour after exposure to 0r, 400r, 500r, 600r, 700r, or 800r of X-ray radiation. Radiation exposure produced a decline in free-cage locomotor activity, an increase in minimum response latency to a single food-rewarded test object, and an increased tendency to balk on a dot-discrimination problem. The results also indicate a threshold to notable effects lying between 400r and 500r.

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RESPONSE RATE DURING X-IRRADIATION AND RECOVERY FOLLOWING IRRADIATION*¹

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A. PROBLEM

The purpose of the present study is to examine the decrement in response rate during irradiation and the recovery of response rate following exposure. It is one of a series of research reports on changes in performance rate as a function of x-irradiation. In all studies, the performances of the subjects were observed during exposure. Some of the findings in the first study with daily dosage rates of 0r, 25r/hr, 50r/hr, 75r/hr, 100r/hr, and 125r/hr were as follows: (a) The overall depression in response rate is a function of both dose rate and numbers of periods of exposure—i.e., the reduction in rate of response is primarily a function of total cumulative dose; (b) the largest source of variance in response rate is the cumulative total dose received by the organism; and (c) the within-day decreasing trend is a function of both dose rate and number of previous days of exposure (2).

In the second study (1) of the series, the subjects were exposed for 20 continuous hours and were required to work for 10 minutes each hour on a five-to-one schedule of reinforcement. One experimental group was exposed to 100r per hour; the other, to 200r per hour. Before the radiation procedures began, the subjects were conditioned to respond when the light was on in the operant-conditioning equipment and to inhibit responding when the box was in darkness. The results show that the decay in response rate is much steeper for the 200r-per-hour animals than for the 100r-per-hour animals and also that there is much less variability from test period to test period. In fact, 200r per hour takes most of the variability out of behavior. After several test periods, the performance decrement for the 200r subjects appears to be a linear function of dose rate over time. There seems also to be a general lack of responsiveness in the animals during continuous exposure at the rates used, and this lack of responsiveness appears to be dose dependent.

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¹ This work was conducted at The Radiobiological Laboratory of The University of Texas and The United States Air Force and was supported (in part) by Contract AF 41(609)-2005 and The School of Aerospace Medicine.

In the present study, the experimental design permits a study of behavior during different radiation rates and intervals as well as recovery of response frequency following irradiation. In the first two studies the decay in response rate was strongly related to the cumulative total-radiation dosage at a given point in time. The present study was designed to maintain equal total dosage even though the dose rates were different.

B. METHODS

1. Subjects

Thirty-six male albino rats of the Sprague-Dawley strain, approximately 100 days of age when training began, were used as subjects. They were housed six to a cage in air-conditioned living quarters and were given water *ad libitum* in the home cages. Each rat was given two large pellets of Purina Lab Chow after each run throughout preliminary training and during radiation and recovery procedures, in addition to the small pellets (0.045 gm each) received for reward during operant-conditioning procedures.

Before irradiation procedures began, the subjects were trained daily in Skinner boxes until the response rate had attained approximately 1200 responses per hour on a 20-to-1 schedule of reinforcement. They were then divided into three matched groups of 12 animals each: controls, 100r/hr daily, and 300r/hr on Days 3, 6, 9, and 12.

2. Radiation and Procedure

The radiation source was a Picker self-rectifying half-wave deep-therapy X-ray unit with radiation parameters as follows: added filtration one-mm aluminum and 0.25-mm copper; voltage, 250-kvp; current, 18 ma. The control animals were in the same room as the experimental animals during irradiation but were placed out of the radiation cone. The 300r-per-hour subjects were placed in the radiation cone but were shielded on radiation Days 1, 2, 4, 5, 7, 8, 10, and 11. All behavioral data were secured while the animals were being irradiated. At the termination of each three-day period during irradiation, both the 100r-per-hour animals and the 300r-per-hour animals had accumulated the same total dose. This gave the 300r-per-hour animals a two-day recovery period between exposures, while the 100r-per-hour animals were subjected to daily irradiation. The final recovery period, following an accumulation dosage of 1200r for both experimental groups, was from the termination of radiation exposure until the first radiation caused death, which was in the 300r group.

C. RESULTS AND DISCUSSION

Because of heterogeneity of variances and a tendency for the means and variances to be correlated, scores were transformed for analysis to their square roots plus 0.5.

Figure 1 shows that, apart from the control group, which performed as expected, the principal performance discrepancy during the irradiation period is for the 300r every-three-days group to show recovery of decreasing amounts after each irradiation; while the 100r-per-day group declines steadily. These

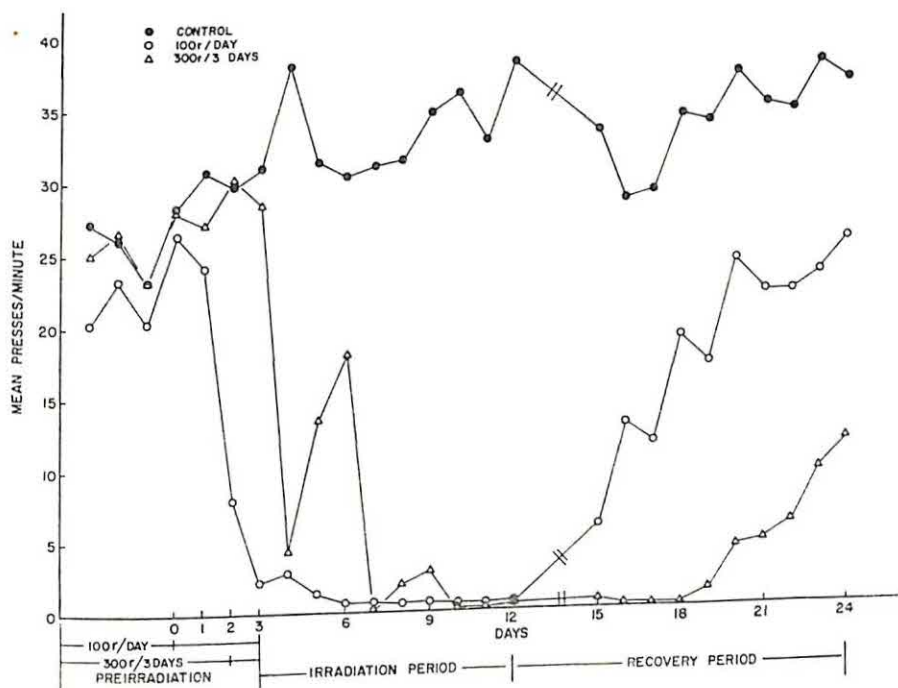


FIGURE 1

MEAN LEVER PASSES PER MINUTE FOR EACH TEST PERIOD OF ONE HOUR

differences were analyzed in two ways. First, the trends in the two groups were compared as the interaction of groups by Days 0, 3, 6, 9, and 11 (these being the days on which the groups had equal cumulative doses). These days also corresponded to the peak of recovery in the 300r group: i.e., the day on which testing was followed by irradiation of this group. This trend difference, which is in the positive acceleration of the decline in the 100r group as opposed to positive acceleration of the decline in the 300r group, is significant beyond the .001 level. A second set of analyses compared linear trends in the two irradiation groups for each of four, three-day periods,

starting with Day 1. After the first period (Days 1 through 3), these periods coincided with recovery in the 300r group. The linear trend differences between the two groups within the four successive periods are significant beyond the .001, .005, and .05 levels respectively. Considered individually, the decline in the 100r group is significant at the .05 level or beyond for the first two periods, after which (as can be seen in Figure 1) performance is asymptotic near the zero level. For the 300r group, the linear component of the recovery trend after each irradiation (Periods 2, 3, and 4) is significant beyond the .05 level.

Whereas the general decline of performance was more abrupt at 100r per day than at 300r every three days, recovery after the radiation treatments were terminated (Day 12) appears to be considerably more rapid in the 100r group. This effect was tested as the interaction of the groups by Days 15 through 20 and is significant beyond the .001 level.

D. SUMMARY

Thirty-six male albino rats of the Sprague-Dawley strain were run on Skinner boxes during radiation exposure. They were divided into three matched groups of 12 animals each: controls (nonirradiated), 100r per hour daily and 300r per hour on Days 3, 6, 9, and 12.

The following results were obtained: (a) the 100r-per-day animals show a rapid and regular decay in response nearly linear in form until an asymptote is reached near zero on Day 7; (b) the animals exposed to 300r at three-day intervals show an irregular overall decline in response rate with increases on the second and third days following the first two exposures; and (c) there is a rapid recovery of response rate in the 100r subjects after irradiation is discontinued on the twelfth day. This recovery is not observed in the 300r subjects.

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THE COMMUNICATION OF AFFECTS IN MONKEYS: COOPERATIVE REWARD CONDITIONING*¹

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A. INTRODUCTION

A number of previous reports (7, 8, 9) have described experiments on the nonverbal communication of affects in rhesus monkeys. Monkeys linked in a cooperative-conditioning situation wherein one of the animals has access only to the conditioning stimuli (stimulus monkey) while its partner has access only to the response mechanism (responder monkey) successfully avoid noxious stimuli provided that the monkey with the response lever is permitted to watch the face of the stimulus monkey throughout the testing session (5, 6). The results of these experiments indicate that monkeys perceive facial expressions connotive of impending pain (fear) in other monkeys and show that a viewing animal responds with appropriate avoidance behavior upon detecting an expressive change in its partner.

The present study is designed to extend the investigation of nonverbal communication in the monkey to an affect other than fear. Anticipation of preferred food appears subjectively to arouse the interest, attention, and excitement of most animals; and since Pavlov's fundamental experiments there is substantial objective data on physiological response in anticipation of food. Therefore, an instrumental-reward paradigm was employed.

Although the previous reports in this area have demonstrated that an observer animal performs appropriate instrumental responses at the times when the stimulus monkey reacts to the conditioned stimulus, more support for the hypothesis that the communication involves the arousal of emotion would be available if one could show that the observer manifests autonomic changes that accompany the detection of affect in the facial expression of a second monkey. A measure of heart-rate response was included in this experi-

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ment to determine whether or not there is autonomic response in both the stimulus and responder monkeys upon presentation of the conditioned stimulus to the stimulus animal.

B. METHOD

1. *Subjects*

Six adolescent-male rhesus monkeys were used in this experiment. These animals had been used six months earlier in a study involving a discriminated avoidance response. Upon completion of that experiment they were returned to the colony quarters where they remained until the present experiment. The animals were tested in squads of three.

2. *Apparatus*

The conditioning stimuli were presented by a tape programmer at intervals of 1.0, 1.5, 2.0, 2.5, or 3.0 minutes. The sequence of intertrial intervals was determined by a table of random numbers and two tapes were prepared for alternate use to minimize any possibility of temporal conditioning. The timing of the stimulus period and the counting and recording of responses were programmed on one of the standard patchcord relay racks of behavioral equipment available commercially. Heart-rate responses were recorded on a Sanborn polygraph through the EKG preamplifier. A closed-circuit television system was used to shape the instrumental response during the first few trials of conditioning and, later, the television circuit was used to link the stimulus animal and the responder during the communication-of-affects stage.

The experimental sessions were conducted in two test rooms located about 60 feet apart. When the doors to the test rooms were closed, there was no audible sound transmission from one room to the other. A third room contained the control and recording equipment and a television monitor. One of the test rooms, the "stimulus" room, contained a wooden tunnel (6" high $\times$ 8" wide $\times$ 32" long) mounted on a table 33 inches from the floor. A lucite stimulus panel was mounted at the end of the tunnel. The stimulus consisted of a one-eighth inch circular band with a three and one-half inch inside diameter scribed into the surface of the plastic. A 24-volt red bulb located in the top of the plastic sheet could be lighted to illuminate the circle in red. The bulb was masked, so that it could not be seen directly by the animal. The appearance of the red-illuminated circle was the CS for reward conditioning. The three and one-half inch center of the circle was cut out, as

was a similar hole in the back of the tunnel, so that the lens of the TV camera could be inserted through the back of the tunnel and through the plastic stimulus panel. Thus, when the monkey looked at the CS it also looked directly into the camera; but, at the same time, the CS was outside the range of the lens. The end of the tunnel facing the animal was equipped with two six-watt fluorescent bulbs to provide adequate lighting for the television system.

The second experimental chamber was equipped with an L-shaped tunnel. The long stem of the L was 46 inches long and the short stem was 13 and one-half inches long. The tunnel tapered from 17 inches wide and 13 inches high at the end of the long stem (dimensions designed to accommodate the screen of a TV monitor) to eight inches wide and six inches high at the end of the short stem. In the right-angle joint of the L a mirror (8" $\times$ 10") was mounted at a 45° angle to permit the subject seated in front of the short stem to see down the length of the tunnel. The floor of the tunnel was 33 inches above the floor of the room. During conditioning sessions a top-lighted stimulus panel similar to the one described above was displayed at the end of the large stem. The panel was 16 inches by 12 inches, with a three-eighth inch circular band having a seven and one-half inches inside diameter. The end of the large stem was closed by a TV monitor which was unlighted during conditioning sessions. The L-shaped tunnel was necessary in the second test room because the system was designed to fit a 21-inch television monitor. Not only was picture quality improved in viewing at a distance of 59 and one-half inches but apparent size of the monkey's face on the monitor was life sized. Likewise, apparent size of the stimuli was approximately equal in the two tunnel arrangements.

3. Procedure

The monkeys were placed in primate-restraining chairs one week prior to the beginning of conditioning sessions. The animals were lightly anesthetized (with sodium pentothal administered intravenously), installed in the chairs, and all of the adjustments for optimal fit of the various contact areas were made. Throughout the experiment the chairs were checked daily to insure that chafing did not occur, and that posture and movement of the animal were maintained at optimal comfort levels. An additional center shelf of lucite was fitted to the chair just below the level of the nipples of the animal to prevent him from reaching chest electrodes. This shelf had a curved, sliding back piece which was tightened against the animal's back just

before the test session, but was loosened during the remainder of the day.

After a one-week period of adaptation to the restraint chair, the conditioning sessions were begun. The monkey in his chair was moved into one of the test rooms and placed in front of the apparatus with his eye level adjusted to the center of the end of the tunnel (36 inches from the floor). A Davis feeder mounted on the wall above the tunnel was connected via tubing to a cup fixed in front of the mouth of the animal. A response lever was attached to the chair, so that it was located at arm level for the animal. The heart rates were obtained by restraining the left leg with a chamois strap and placing a ground electrode on a shaved area on the thigh. The active electrodes were attached to the center and left side of the chest on shaved areas. Shielded cables were used to connect these electrodes to the EKG polygraph in the control room. The room lights were left on for the first two or three conditioning sessions, so that the TV camera could be used to "shape" the instrumental response.

When the animal was prepared for the conditioning session, the experimenter left the test room and a five-minute period was given to permit the animal to return toward baseline activity. After five minutes the programmed tape was started and the 20-trial, 45-minute conditioning session was begun. The CS was the red illumination of the circular band in the lucite stimulus panel. The stimulus period was 10 seconds, and a bar press within that period activated the feeder to deliver a 45-mg dextrose tablet. Each of the first four bar presses per trial delivered a reward, but after four responses the stimulus was automatically terminated; and further responses did not produce reward. It was possible for the animal to secure up to 80 tablets per session. If fewer than four responses were made on a trial, the stimulus light was terminated after 10 seconds.

Shaping of the response via the television circuit was discontinued after the monkey had performed five or six rewarded responses—ordinarily within the first three sessions.

The conditioning sessions were continued for all animals in the squad until the slowest learner had met the acquisition criterion: viz., three consecutive test sessions in which the observed CRs were significantly greater than chance-expected CRs. Expected CRs were determined empirically for each session by dividing the total number of bar-pressing responses that occurred during the session when the CS was not present (SRs) by 250, the number of 10-second intervals between trials. The resulting figure was the number of SRs per 10-second intervals. Multiplying this figure by 20, the number of trials, gave an estimate of the spurious or chance CRs that could have been

expected during the session. To minimize the extent of overlearning in the monkeys that met criterion, the slow learners in a squad were given a morning and an afternoon conditioning session each day, while those animals reaching criterion received but a single session daily.

When all animals in the squad had achieved the acquisition criterion, tests on the communication of affects were begun. One of the animals was selected as the stimulus animal for the first series of tests. That monkey was placed in the stimulus test room in front of the stimulus tunnel. The food-delivery mechanism was attached to the chair, but the response bar was not attached. The TV camera was inserted through the holes in the back of the tunnel and stimulus panel and focused on the face and head of the stimulus monkey.

One of the remaining animals in the squad was placed before the tunnel in the second test room. The stimulus panel was removed from the tunnel, and the TV monitor was switched on. Both the feeder and the response bar were attached to the restraining chair.

The experimenters then retired to the control room. After a five-minute rest a one-minute baseline EKG was secured for each animal, the tape programmer was switched on, and the test trials were begun. The conditioning program was run exactly as in training except that the CS was delivered only to the stimulus monkey, while the responder alone could activate the paralleled feeders with appropriate instrumental bar presses. As in training, up to four pellets could be secured on any given trial. Twenty trials were given during the 45-minute test session. At the conclusion of the session a one-minute EKG sample was secured; then the feeders and bar attachments were removed from the chairs, and the responder animal was taken out of his test room. The third animal of the group was then placed in the responder room and, about two hours later, another test session was begun. Thus, the stimulus animal served for two sessions per day, one session for each of the other members of the squad. After approximately 20 sessions one of the other animals was switched to the role of stimulus, and finally (about 20 sessions later), the remaining animal became the stimulus monkey. Each animal, therefore, was the stimulus for each of the other two monkeys and, in turn, had an opportunity to respond to each one of them.

Heart-rate recording was begun in the first squad of animals on the 40th conditioning session and continued for the remainder of the experiment. These measures were collected throughout the entire experimental period for the second squad of three animals. The EKG was begun six seconds prior to each trial and continued during the 10-second stimulus period and

for two seconds following stimulus termination. In each case, the records were divided into standard six-second periods for counting. For each trial a prestimulus six-second count, a six-second count beginning with stimulus onset, and a six-second count overlapping termination of the stimulus were recorded.

C. RESULTS

1. *Conditioning*

On the average, the six animals in the main experiment met the criterion of conditioning (three consecutive significant sessions) in 25.16 sessions (median 22.5, range 19 to 40 sessions). Because of the restriction that all animals in a squad were required to reach the criterion before the communication-of-affects tests were begun, the total number of sessions was greater than the number of sessions required to reach the criterion would imply. This was particularly true of the first squad of animals because the slowest learner in that group did not meet criterion until the 40th session. The following day the heart-rate recordings were introduced for the first time in the first squad, and the animals were continued on the training schedule until the criterion was achieved again. The restraint imposed by the use of chest and leg electrodes was not particularly severe, and two of the three animals in the squad did not appear to be unduly disturbed by the new equipment—but the third animal (No. 153, which was the slowest learner initially) was totally disrupted by the introduction of heart-rate recording equipment. It required exactly the same number of sessions, 40, to bring this animal back to the learning criterion with the heart-rate measures that had been required in the initial learning. The numbers of sessions and significant runs during conditioning are given in Table 1.

The discrepancy between numbers of test sessions for animals in the first squad during the retraining with heart-rate electrodes was attributable to the procedure of administering two sessions a day to the monkeys that were performing poorly; thus No. 153 received 40 sessions in 20 days, while No. 156 had 17 sessions in 17 days.

The conditioned heart-rate response for each of the animals during the three criterial sessions of acquisition is shown in Figure 1. The R waves were counted for 18 consecutive seconds on each trial. The record for the first six seconds was obtained before stimulus presentation in order to provide a basis for estimating prestimulus level and variability. The next 12 seconds, beginning with stimulus onset, gave a measure of the autonomic response to the conditioned stimulus, the performance of conditioned responses, and the

TABLE 1
SESSIONS FOR THE TWO SQUADS OF MONKEYS DURING PRELIMINARY TRAINING

Animal no.	Total sessions	First significant session	Criterion session	Total significant sessions
153 Pre H.R.	40	38	40	3
H.R.	40	38	40	3
154 Pre H.R.	40	34	36	7
H.R.	30	4	18	19
156 Pre H.R.	40	19	26	17
H.R.	17	1	3	17
157	20	15	20	4
158	20	16	20	4
160	20	10	19	6

receipt of reward. In actual practice, the beats were summed in two-second intervals as a matter of convenience in the recording and the treatment of the data.

Data for each animal were analyzed separately. On each test session baseline measures were taken of heart rate for one minute prior to the beginning of the trials and for one minute following the completion of the trials. Each baseline was divided into 10 consecutive six-second periods, and the heart rate was counted for each interval. The difference in rate between consecutive intervals was determined for each testing day. The mean ($\pm$ three standard deviations) of the differences was then determined for the total sessions during conditioning. The figures gave an estimate of the amount of fluctuation that one might anticipate in the heart rate of monkeys in the test situation when conditioning stimuli were absent. The conditioning data were assessed by subtracting the heart rate of the six-second period prior to the presentation of the CS from that for the period from zero to six seconds after the onset of CS (D_1) and from the period seven to 12 seconds after CS onset (D_2). The heart-rate increases during the three criterial sessions (Figure 1) are significant beyond the .01 level for all animals except No. 154 (whose heart rate changes are not statistically significant) and No. 157 (who reached significance for both zero to six, and seven to 12, seconds) at the .05 level.

The prestimulus rates vary from 97.5 bpm for No. 156 to 185 bpm for No. 154 (Figure 1). These relative levels of baseline autonomic activity are quite characteristic of the individual monkeys in the experiment. The data were not examined for the law of initial values (4) but it is noteworthy,

perhaps, that monkey No. 154, which consistently had the highest levels of baseline heart rate, was the only animal which failed to show significant cardiac acceleration to the conditioning stimulus.

2. The Communication of Affects

In the communication-of-affects test, each monkey in a squad was paired with each other member of his squad. Because, in each pairing, the animal

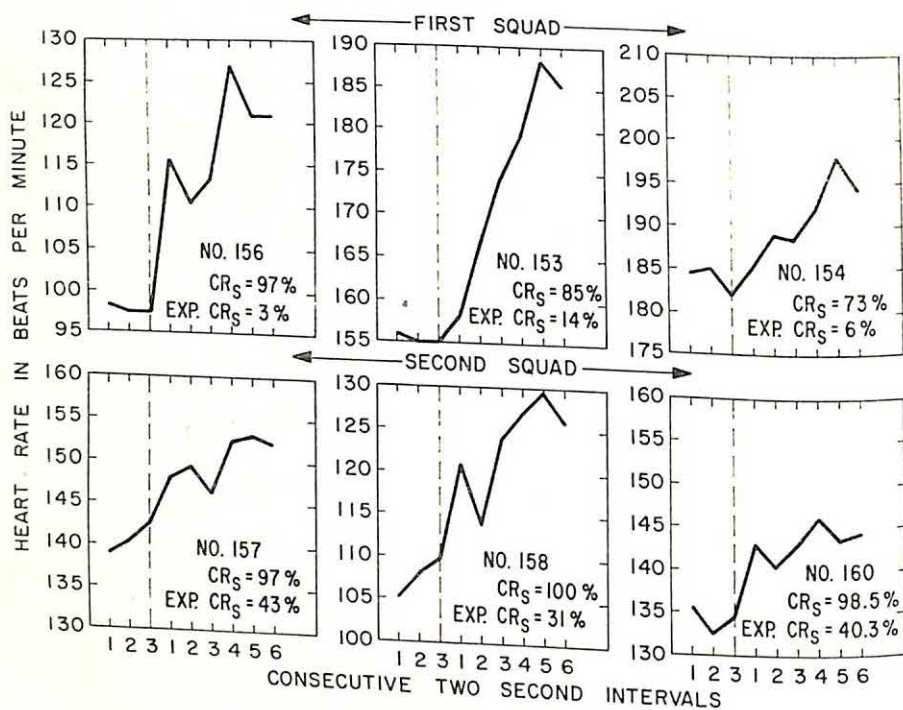


FIGURE 1
THE CONDITIONED CARDIAC RESPONSE OF THE SIX MONKEYS DURING THE
THREE CRITERIAL SESSIONS

Animal number, CRs observed, and chance-expected CRs for these sessions are shown in each panel. The vertical line at 3 indicates onset of CS.

served on one occasion as the stimulus and again as the responder, there were six pairings within each squad of animals.

The data in Table 2 show that a significant communication of affect with regard to instrumental behavior occurs in only six of the 12 pairings tested. It would appear that, in this experiment at least, the critical variable in the communication chain is the responder monkey. The cardiac acceleration upon

TABLE 2
THE HEART-RATE RESPONSES OF STIMULUS AND RESPONDER ANIMALS DURING COMMUNICATION-OF-AFFECTS TESTS

Stimulus animal	D ₁ heart-rate changes BPM	D ₂ heart-rate changes BPM	Total sessions	Number of significant sessions (Behavioral)	Responder animal	D ₁ heart-rate changes	D ₂ heart-rate changes
154	4.2	11.7**	20	9	156	5.6*	15.5**
154	4.5	10.7**	20	0	153	1.2	3.8
153	9.8**	24.4**	20	20	156	9.6**	18.2**
153	8.8**	24.1**	18	0	154	-1.8	-3.2
156	13.0**	18.2**	20	0	153	1.0	3.9
156	10.9**	19.1**	28	0	154	-.4	-1.3
157	9.2*	13.7**	10	0	160	-.5	-.55
157	7.0	12.5**	10	9	158	12.4**	23.6**
158	12.9**	29.8**	12	0	160	.7	1.8
158	14.8**	26.0**	25	9	157	3.0	7.8**
160	17.3**	22.4**	24	10	158	7.9*	16.3**
160	15.5**	23.6**	25	6	157	2.4	5.3

* $p < .05$.

** $p < .01$.

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stimulus presentation is significant for each stimulus animal in each pairing. Further, examination of the latency, intensity, and duration of the conditioned cardiac response in the stimulus animals reveals that these monkeys respond to the conditioned stimulus in virtually the same fashion with the two responders despite the fact that with one pairing food rewards are obtained in the cases of successful communication; while in the second pairing no reinforcements are delivered. Likewise, there are no obvious behavioral differences (as monitored on television) between reactions to the CS on the part of the stimulus monkey on successful *vs.* unsuccessful pairings except for a growing restlessness toward the end of nonreward sessions. Further evidence for the role of the responder in this communication net is the observation that the same three animals responded successfully to both stimulus monkeys with which they were paired, while the remaining three animals did not respond appropriately in any of their pairings.

The cardiac conditioned response of the successful responders was of approximately the same magnitude during communication-of-affects tests as it was during the presentation of the conditioned stimulus. Figure 2 presents the heart-rate responses of the stimulus and responder for those sessions in which significant instrumental behavior was observed. It is noteworthy that baseline levels have shifted downward in comparison with that shown by the data in Figure 1. This phenomenon probably reflects a continuing adaptation to the conditions of the experimental situation. A remarkable consistency of amplitude and pattern in the heart-rate response of individual animals throughout the experimental procedures is also suggested by the data in Figure 2.

3. Discussion

The studies reported provide experimental evidence that some monkeys can detect changes in facial expression or head movement of other monkeys receiving stimuli associated with reward. The perception and correct interpretation of facial cues are accompanied by changes in heart rate that are similar both qualitatively and quantitatively to those produced in response to the conditioned stimulus in the training situation.

Since half of the animals showed no evidence of communication it is evident that the communication of affects in an experimental food-reward situation is by no means an invariable phenomenon. Failure to establish communication was apparently primarily a flaw in reception on the part of the responder rather than a lack of expressiveness on the part of the stimulus animal.

Previous reports have described cooperative-avoidance conditioning in the

monkey (5, 6). In the case of avoidance, it has been shown that very strong and consistent avoidance behavior can be maintained on the basis of cue stimuli from facial expressions of stimulus monkeys repeatedly exposed to avoidance stimuli. While the cooperative-avoidance conditioning of the earlier study and the cooperative-reward conditioning of this experiment cannot be strictly compared, it seems clear that communication based on aversive cues is much more universal and powerful among monkeys than is communication

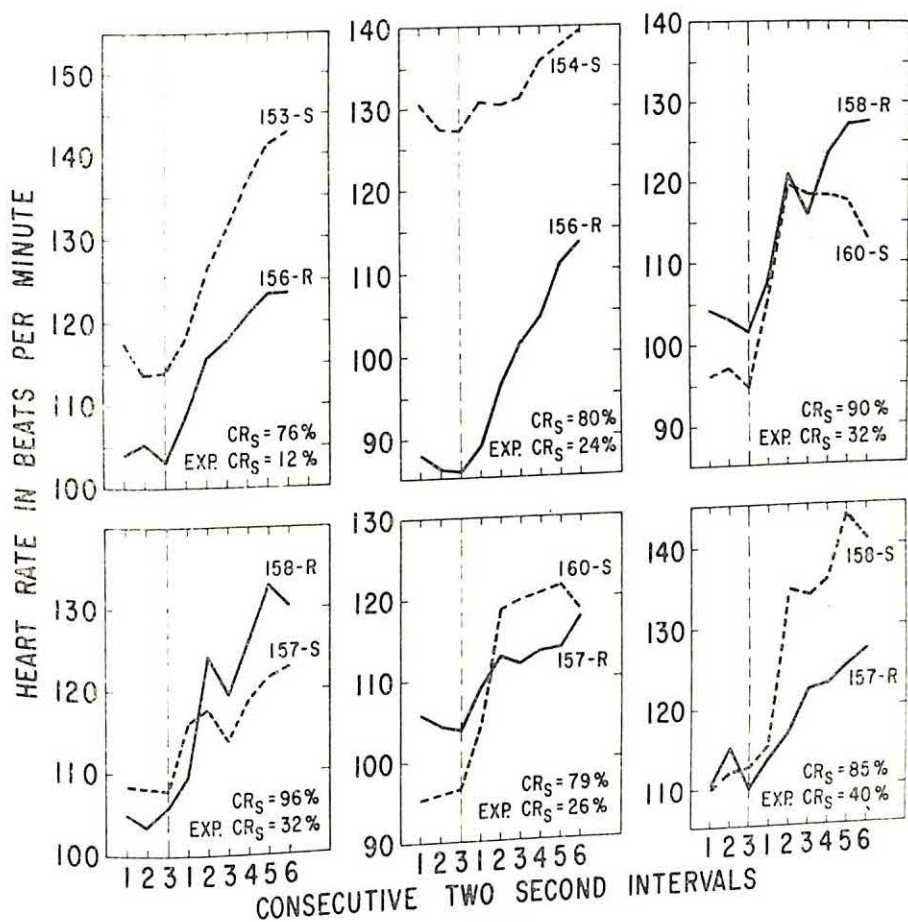


FIGURE 2

THE CONDITIONED CARDIAC RESPONSE OF SUCCESSFUL PAIRS OF MONKEYS
DURING COMMUNICATION-OF-AFFECTS TESTS

Data are from significant sessions only. Animal identifications, CRs observed, and chance-expected CRs for these sessions are shown in each panel.

based on anticipation of reward. There are several possible explanations for this difference.

No attempt was made to equate drive conditions in the two experiments. In the avoidance situation, the minimum shock level consistent with stable performance was used, but the relationship between the "fear" elicited by such a shock and the "anticipation" of four pellets of food is not known. In the two experiments, there is also a discrepancy between the consequences of failure to respond. In the avoidance situation, if the responder did not press the bar upon receipt of cues from the stimulus monkey, primary reinforcement ensued in the form of aversive shock. In the present study, lack of response meant simply that the animals did not receive primary reinforcement. Thus, from the very nature of the paradigm, the avoidance behavior appears more likely to persist than does reward in a cooperative-conditioning situation.

It is probable that the communication of "fear," "anxiety," or "apprehension" of impending danger is more prepotent than the communication of available but limited rewards. A large number of field studies of social aggregations of infrahuman primates (1, 2, 3) have shown that the animals are sensitive to movements, cries, and gestures by members of the group connoting aggression, predator approach, territorial invasion by other groups, etc. At the same time, it has been demonstrated that competition for available food is determined largely by the social-dominance relationships within the group. Consequently, individuals low in the dominance hierarchy are unlikely to advertise that they have access to a supply of preferred tidbits. In captivity it is common for a submissive rhesus monkey to retreat to a corner of the cage remote from its dominant cagemate, turn its back, huddle over the food, and eat as surreptitiously as possible until the food is consumed. It is possible that the facial expressions and postures in anticipation of reward by their very nature are more covert than the facial expressions associated with impending danger. Observations of the face of the stimulus animal on the control-room monitor are in accord with such conjectures. The principal change noted in the stimulus monkey upon the stimulus presentation was a sudden cessation of the random behaviors which were ongoing between trials and a quiet and intent fixation of the stimulus panel. Toward the end of a trial, if no rewards had been delivered the monkey sometimes glanced toward the feeder mechanism. Successful communication appeared to depend primarily on the discrimination by the responder of the intent stare of the stimulus animal during trial presentation.

The heart-rate measures that were obtained in the present experiment

were not intended to serve exclusively as an index of anticipation of reward. It is clear that the cardiac response is a confounded aggregate of anticipation, response, the securing of reward, and ingestion. While these various aspects of the cardiac response cannot be delineated in these data, there can be no doubt that CS presentation per se evokes significant heart-rate changes. As is evident from the data in Table 2, there are significant accelerations in rate for stimulus monkeys even in those pairings for which communication is not successful. In such instances, the stimulus animal receives only panel illumination without instrumental behavior or delivery and ingestion of the reward. The magnitude of accelerative response does not differ between rewarded and unrewarded pairings as far as the stimulus animal is concerned.

In retrospect, our use of a complex reward contingency (i.e., the rewarding of the first four instrumental responses during the 10-second stimulus period) was probably unfortunate. The rationale for this particular system of reward was to lengthen the period of CS presentation throughout both initial learning and communication of affects. As long as the stimulus panel remained illuminated, reward was available. In practice, because the first bar press under such condition elicited a reward, the animals merely had to learn to follow rewarded responses with additional bar presses until reinforcements no longer ensued. Thus, rewarded responses other than the initial one on each trial were not really interpretable. In further experiments with cooperative-reward conditioning a single relatively large reward will be delivered on the response that follows CS presentation.

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URINARY SODIUM AND POTASSIUM AND PROLONGED ENVIRONMENTAL STRESS*¹

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A. INTRODUCTION

One of the well-documented effects of environmental stress is the increased pituitary-adrenocortical activity (7, 8, 14, 15). Because the pituitary and adrenals initiate quantitative as well as qualitative changes in the urine, urine is affected by stress via the aforementioned endocrine structures. Several investigators (2, 5, 10, 22) have reported a urinary sodium (Na) retention and a potassium (K) loss following emotional stress. These electrolyte disturbances imply a hyperfunction of desoxycorticosterone (DOC) by the adrenal cortex during stress (17). Although aldosterone is approximately 25 times more effective than desoxycorticosterone in regulating electrolyte metabolism (4, p. 20; 21), aldosterone is not necessarily implicated in the stress picture because it is secreted independently of pituitary function (18). Of the mineralocorticoids, this leaves desoxycorticosterone primarily. On the other hand, we find that the glucocorticoids—not the mineralocorticoids—generally have been more active during environmental stress (3, 12, 16, 20, 23). Thus the role of mineralocorticoids, such as DOC, during stress is ambiguous. The present study represents an attempt to clarify this problem by (a) measuring sodium-potassium balance during prolonged stress, and (b) monitoring pituitary-adrenocortical function via blood eosinophils during the stress period.

B. MATERIALS AND METHODS

1. Subjects

The study utilized 48 male Sprague-Dawley rats, 90 days old at the beginning of the experiment.

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2. Apparatus

The experimental-stress chambers consisted of combination metabolism cages and grid boxes. They were seven inches wide, eight inches deep, and seven inches high. All walls were wood except the front wall, which consisted of plastic and served as the door. A two-inch hole was located in the ceiling beyond which a small speaker was attached. The floor was composed of three-sixteenth-inch brass rods spaced one-half inch apart. Attached outside the door was a graduated water cylinder. The drinking spout protruded through the door into the chamber. A plastic food box was also attached outside the door. Adjacent holes in the door and the food box permitted entry only of the head of the animal. This arrangement allowed feeding and reduced food spilling to a minimum. To collect urine, a square funnel was suspended beneath the grid floor. Between the grid floor and funnel, a removable fine-wire screen was positioned to prevent feces and animal fur from falling into the funnel. Twelve home cages were similarly equipped with food box, drinking cylinder, and funnel. Each chamber was placed inside a ventilated picnic cooler. One unit, then, consisted of a chamber within a cooler. With the door of the cooler in place, the chambers were isolated from one another with respect to sound and provided a constant physical environment. A Scientific Prototype shock source and scrambler (Model No. SS13) was used to charge the chamber grids. Tone was supplied by an Eico audiogenerator (Model 377). Presentation of stimulus events was controlled by a Gerbrands tape programmer.

3. Procedure

Prior to the stress period, two blood eosinophil determinations and three urinary Na and K measures were obtained from all subjects. The number of circulating eosinophils per 100 leukocytes was counted for each rat. Na and K determinations were obtained using a standard flame photometric process with a Baird-Atomic KY-2 flame photometer. All Na and K measures were obtained from 24-hour urine specimen.

Thirty-six animals were placed in their individual chambers for a seven-day habituation period. Twelve animals remained in individual home cages in the colony room. On the eighth day, the stress schedule was initiated. This consisted of a four-second 1700-cps tone followed immediately by a 0.5-second 3.5-ma shock presented randomly with an average interval between pairings of four minutes. Twelve animals, designated tone-shock (T-S)

animals, received both tone and shock. Twelve animals, designated no tone-shock (NT-S) animals, received only shock. Twelve animals, designated no tone-no shock (NT-NS) animals, received neither tone nor shock and served as chamber-control animals. The 12 rats assigned to home cages served as home-cage controls (HC). The stress period lasted 20 hours for a period of 22 days. Blood differentials were taken every fourth day during the stress period. Urine Na and K determinations were carried out every two days. All animals had continuous access to food and water. Upon termination of the stress period, all animals were sacrificed. Adrenals were removed, quick frozen, and stored at minus 40 degrees centigrade. They were subsequently weighed on a Mettler analytical balance.

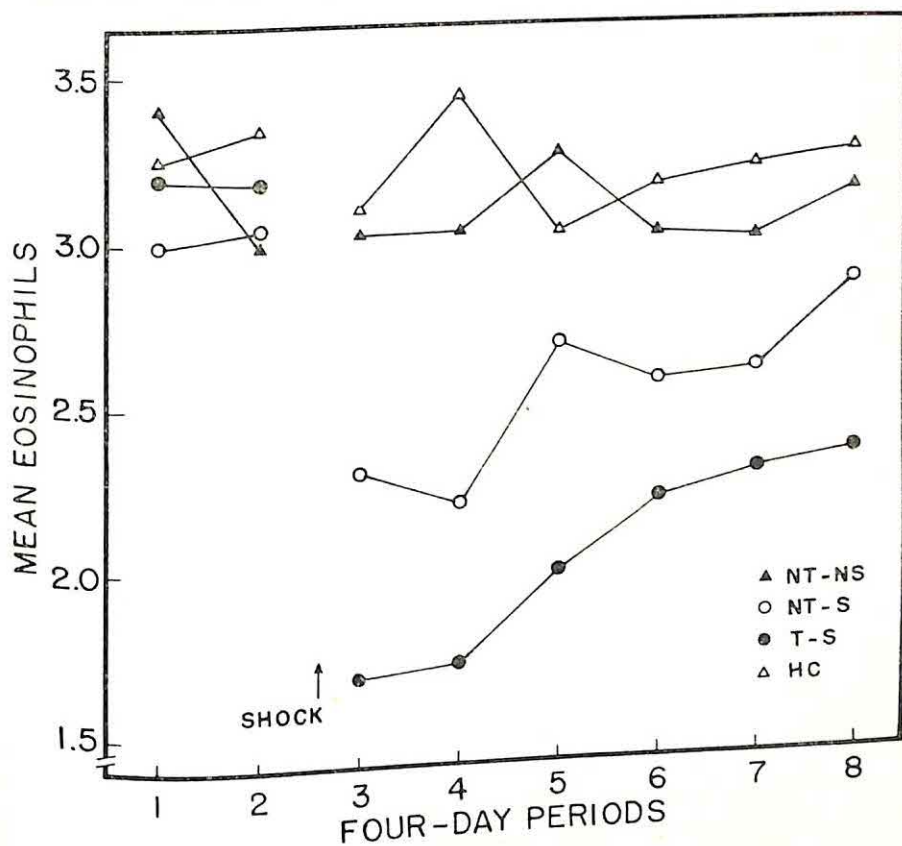


FIGURE 1
MEAN BLOOD EOSINOPHILS FOR PERIODS PRECEDING AND FOLLOWING SHOCK STRESS

C. RESULTS

Analysis of variance for the eosinophil data shows significant differences for the main effect of treatment groups ($F = 10.34$; $df = 3, 44$; $p < .01$). The significant treatment-group variance is attributable to the low eosinophil values for T-S and NT-S animals. Figure 1 illustrates these data. Comparison of group means for the adrenal weight-body weight ratios shows a significant F ratio ($p < .01$) and reveals a significant adrenal hypertrophy for the T-S animals. These data are presented in Table 1. The eosinophil and adrenal data indicate a significant hyperfunction of the pituitary-adrenocortical axis during the stress period. Evaluation of electrolytes in terms of milliequivalents per liter (mEq/L.) show a minor change in

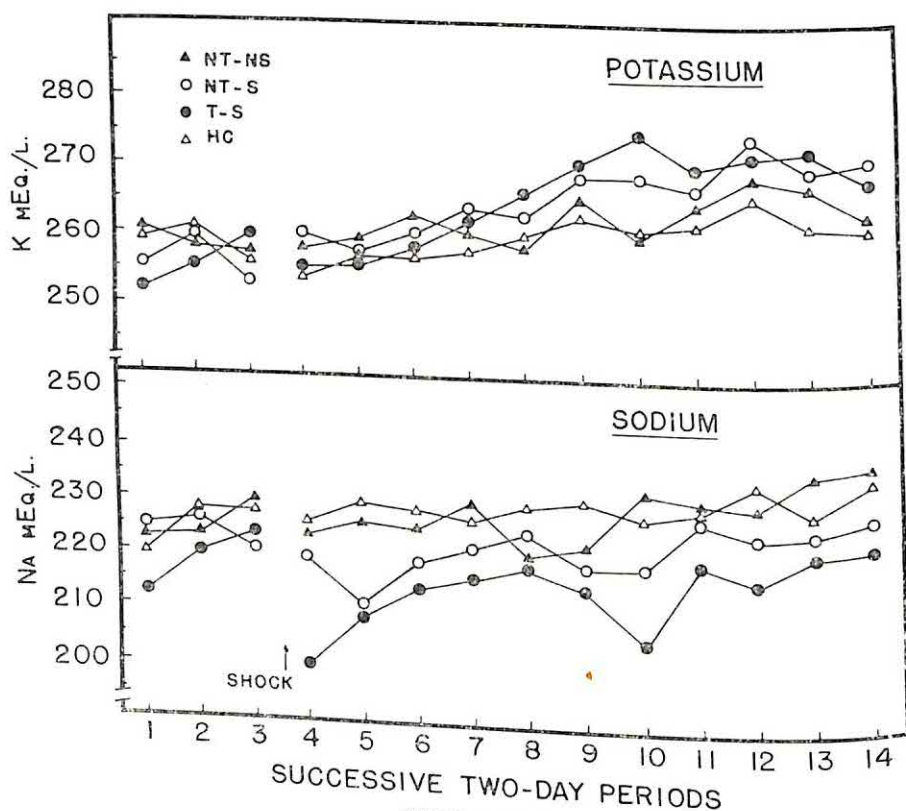


FIGURE 2
MEAN POTASSIUM AND SODIUM DATA IN mEq./L. FOR THE
HABITUATION AND SHOCK-STRESS PERIODS

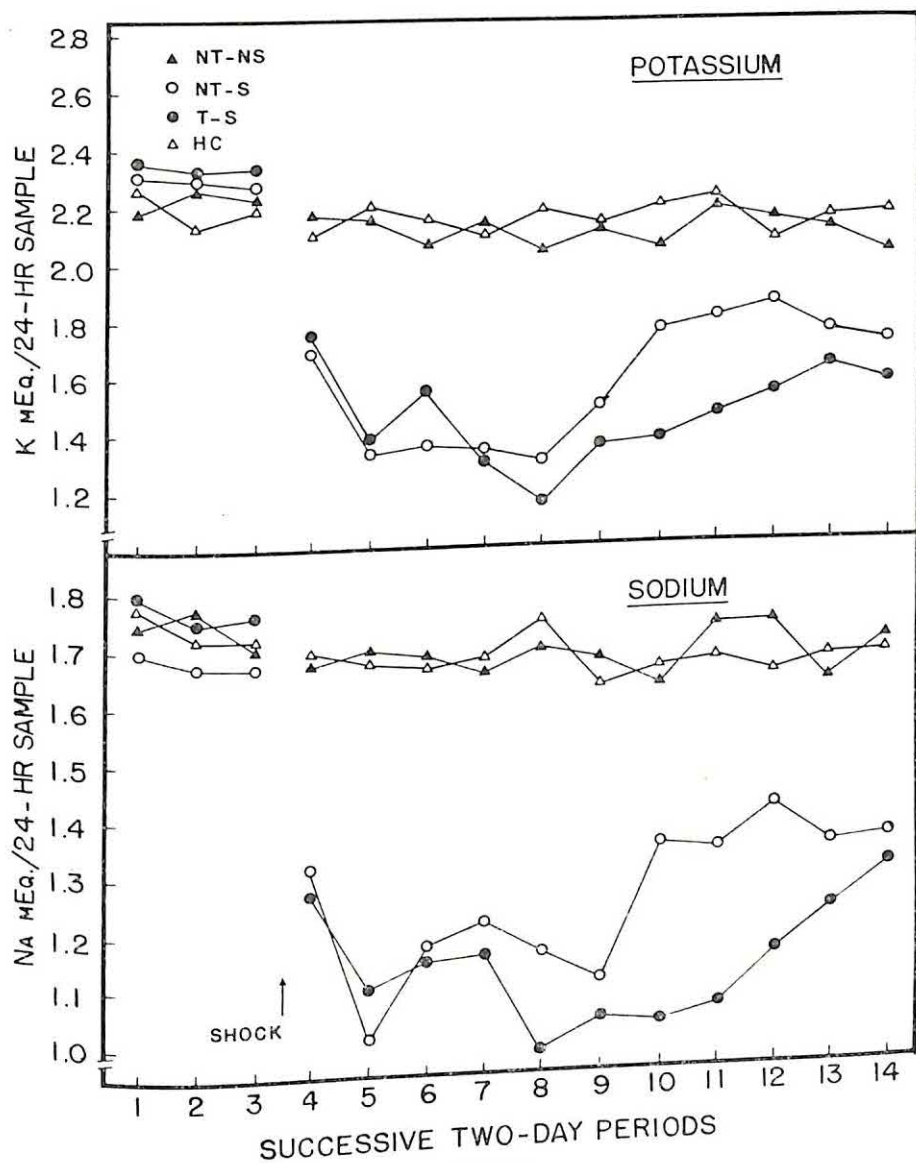


FIGURE 3
 MEAN POTASSIUM AND SODIUM DATA CORRECTED FOR URINE VOLUME (mEq./24-HOUR SAMPLE) FOR THE HABITUATION AND SHOCK-STRESS PERIODS

TABLE 1
MEANS AND STANDARD DEVIATIONS FOR ADRENAL WEIGHT-BODY WEIGHT RATIOS

Parameters	Experimental treatments			Tone-shock
	Home-cage control	No tone-no shock	No tone-shock	
Mean	.1178	.1190	.1248	.1673
SD	.0139	.0167	.0196	.0187

the direction of Na retention and K loss for the T-S animals, but these deviations are not significantly different (Figure 2). Analysis of the same data, after correcting for urine volume, reveals significantly lower K and Na values for the T-S and the NT-S animals during the stress period. These results, however, which are illustrated in Figure 3, are an artifact of the stress-induced antidiuretic effect. During the stress period, the mean 24-hour urine volume for the T-S and the NT-S animals is significantly lower than that for the control animals ($F = 9.52$; $df = 3, 44$; $p < .01$).

D. DISCUSSION

Eosinopenia (1, 6, 9, 19) and adrenal hypertrophy (11, 13) represent reliable indices of pituitary-adrenocortical activity. The blood and adrenal data gathered in the present study indicate that the experimental procedure was instrumental in initiating a pronounced stress reaction in experimental subjects. Corresponding measures of Na and K, in terms of mEq./l., do not reveal a disturbance of electrolyte balance. It is reasonable to infer that mineralocorticoids are not an integral part of the physiological response to chronic environmental stress. The authors conclude (a) that prolonged environmental stress initiates a distinct pituitary-adrenocortical response and (b) that the adrenal mineralocorticoids do not contribute significantly to this stress response.

E. SUMMARY

In this study the authors investigated the relationship between chronic environmental stress and the adrenal mineralocorticoid response. Twelve rats were subjected to tone-shock pairings 20 hours daily for 22 days. Twelve rats received only shock, 12 rats received neither shock nor tone, and 12 rats served as home-cage controls. Blood eosinophils and urinary Na and K were collected during the prestress and stress periods. Following the stress period, adrenals were removed and weighed. Stress rats manifest a significant eosinopenia and adrenal hypertrophy. Estimates of Na and K during the stress period do not manifest a shift in electrolyte balance for stress animals.

The authors conclude that the adrenal mineralocorticoids do not participate in the physiological response to chronic environmental stress.

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THE INVISIBLE CHILD IN THE ARITHMETIC CLASS:
A STUDY OF TEACHER-PUPIL INTERACTION*

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A. INTRODUCTION

In this investigation, the interactions of 12 fifth and sixth grade teachers with selected pupils in arithmetic classes were studied in an effort to determine whether or not a relationship exists between their interactions and the academic reputation of pupils.

Of particular significance is the interaction between teachers and *invisible* pupils. The invisible pupil is a pupil whose arithmetic-test ability is high in relation to the average ability of his class, but whose ability is not recognized by his peers. He can be contrasted with the *visible* pupil, who is of similar high arithmetic-test ability, but whose accomplishments are perceived by other members of his class.

One's self-concept may be heavily influenced by the opinions others hold of him. In the case of the invisible pupil, it seems possible that the low evaluation made of him by his peers may result eventually in a similar self-evaluation—made of him by his peers may result eventually in a similar self-evaluation—to the detriment of the individual and society.

This investigation had its inception in the results of an earlier inquiry (1) into the functioning of small problem-solving groups. In that experiment, three-member groups of elementary-school children worked cooperatively upon sets of arithmetic or social-studies problems. Each group included one member (the high-ability subject) who had significantly higher task-related ability than his coworkers. In half the groups, the high-ability subject was the one who was recognized beforehand by his peers as one of the most capable members of the class (the visible pupil). In the other half of the groups, the high-ability member was not so perceived (the invisible pupil).

A variety of hypotheses were formulated concerning anticipated differences in the productivity of groups when the potential leaders were perceived so differently. However, these groups did not differ in the number of problems they solved nor in the roles played by the high-ability member. The high-ability member (whether visible or invisible) supplied slightly more than

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half the final solutions to problems accepted by the group as a whole. In short, both the visible and the invisible members appeared to function in the group solely as the experimental estimates of their ability suggested they should; that is, they worked diligently at suggesting solutions to problems, influenced others (by various means) to accept the suggested solutions, and generally played the role of the group leader. The problem-solving sessions did not seem to influence the extent to which the members of the group recognized the contribution of the high-ability member.

The foregoing results left us perplexed about how elementary pupils earn reputations for achievement and productivity. Our analyses failed to reflect any behavioral differences between visible and invisible pupils, but continued to reflect differences between them in the evaluation by their peers.

B. CONCEPTS AND HYPOTHESES

Because pupils spend so much time together in the classroom, and because a substantial fraction of classroom time is usually devoted to interaction between teacher and pupils, pupil-teacher interaction would appear to provide a fruitful locus for analysis, particularly on the assumption that the teacher's relations with an individual pupil influences the way in which the pupil is regarded by his classmates. It follows that differential patterns of interaction between the teacher and the pupil can result in differential evaluation by peers.

Data for this study were based upon teachers' interactions with three types of pupils: visible pupils, invisible pupils, and average pupils.

1. *Visible Pupils*

The visible pupil in the classroom is one whose academic achievement is superior to the average achievement of his class and whose reputation among his peers matches that superiority. Operationally, a pupil was identified as visible if his raw score on the arithmetic-reasoning section of the Stanford Achievement Test, Intermediate, Form J, fell one standard deviation or higher above the mean score for his class *and* if the number of nominations he received from his classmates in response to the sociometric question "Who are the three or four pupils in this class who are best in arithmetic?" was greater than one standard deviation above the average number of nominations given to his classmates.

2. *Invisible Pupils*

An invisible pupil is one whose academic achievement is superior to the average achievement of his class, but whose reputation among his peers does

not match that superiority. Operationally, a pupil was identified as invisible if his raw score on arithmetic reasoning fell one standard deviation or higher above the mean score for his class and if the number of sociometric nominations he received was below or equal to the average number given to his classmates.

3. *Average Pupils*

An average pupil is a pupil whose achievement reflects the mean for the group and whose peers regard him as of average ability.

4. *Teacher-Pupil Interaction*

Typically, in the intermediate-grade arithmetic class, children are involved in working problems and examples (either privately at their desks, or publicly in responding orally to questions from the teacher or engaging in drill or other kinds of arithmetic practice at the blackboard). Some degree of confirmation or disconfirmation by the teacher of individual pupils' arithmetic problem-solving behavior can be expected to occur publicly (that is, in the sight or hearing of all members of the class). Because arithmetic is relatively explicit in its demands upon performance, teachers' confirmation of pupil behavior can be precise. Throughout the school semester or year, pupils have repeated opportunities to observe the success or failure of others (as well as of themselves) as they engage in a variety of classroom situations. Obviously, not all pupils have equal success in the engagements, but it does not seem unreasonable to assume that children acquire some opinions about the relative level of mathematical skills of their classmates, based upon some informal assessments of public performance. How are pupils' perceptions of each other influenced (if they are influenced) by interactions between the teacher and any given pupil? Several possibilities are expressed in the hypotheses that follow.

a. *Hypothesis No. 1.* The mean number of interactions between the teacher and a visible pupil is significantly greater than the mean number of interactions between the teacher and invisible pupils and between the teacher and average pupils.

Pupils differ in the sheer frequency with which they interact with the teacher. Peers may be able to improve the accuracy of their estimates of a classmate's ability with increase in the number of occasions in which he engages in interaction with the teacher. If visible pupils participate in more interaction episodes than do other pupils, their classmates have more opportunity to recognize ability than is the case of invisible pupils.

b. *Hypothesis No. 2.* There is a significant difference in the mean number

of pupil-initiated interactions among visible, invisible, and average pupils. The difference favors visible pupils.

Interaction in the classroom occurs under special conditions that set it apart from interaction in other kinds of settings. In most cases the teacher originates the interaction. The teacher has the prerogative of raising questions, setting tasks, and evaluating behavior independently of the desires of pupils. In the arithmetic class the teacher is free to demand interaction with any pupil at any time, but the converse is not altogether true. Usually pupils interact with the teacher only when, in effect, the teacher signals that such interaction is permissible. While interaction in the classroom can be initiated either by the teacher or the pupil, it is important to remember that pupil-initiated interactions are contingent upon teacher sanction.

Presumably a pupil will choose to initiate interaction (in the sense of volunteering to answer a question or solve a problem) more frequently when he feels he can do so adequately or correctly than when he is less sure of his success. If pupils differ in the frequency with which they initiate interaction, the frequency of their correct performances should vary in proportion and contribute to the pool of information available to peers for forming judgments about arithmetic ability.

Further, one can argue that pupils differ in the frequency with which they attempt to initiate interaction with the teacher. Three classes of attempts can be identified: (a) successful attempts (i.e., attempts that result in interaction with the teacher), (b) withdrawn attempts (i.e., attempts made but withdrawn), and (c) ignored attempts (i.e., attempts that are ignored).

In recitation a pupil may raise his hand but lower it before he or another pupil has been recognized by the teacher (a withdrawn attempt). A pupil may signal his intention to interact, does not withdraw; but is not recognized by the teacher (an ignored attempt).

c. Hypothesis No. 3. Visible pupils attempt interaction with the teacher more frequently than do either invisible pupils or average pupils. This hypothesis does not differentiate among the three types of attempted interaction specified in the previous paragraph.

d. Hypothesis No. 4. The greatest frequency of withdrawn attempts occurs among invisible pupils. It is assumed that this result might occur because of the insecurity of the invisible pupil in group situations or for other reasons, with the consequence that invisible pupils impose a limitation on their opportunities to exhibit their ability.

e. Hypothesis No. 5. Attempts by visible pupils to interact with the teacher are less frequently ignored than are the attempts of other pupils.

f. Hypothesis No. 6a. To this point, the hypotheses have dealt only with the teachers' strategy in initiating interaction with pupils or allowing them to interact with him. But the teacher also plays an important role in the classroom as an evaluator of pupil performance. The final hypothesis of this study concerns the evaluative role of the teacher. It is stated in two parts: Hypothesis 6a and Hypothesis 6b.

Hypothesis 6a is that visible pupils receive more positive feedback from the teacher than do other pupils.

g. Hypothesis No. 6b. Hypothesis 6b is that visible pupils receive less negative feedback from the teacher than do average or invisible pupils.

If one determinant of a pupil's academic status in the classroom is the frequency of his interaction, certainly another must be the type of feedback that he receives from the teacher. Although the teacher may intend feedback about the adequacy or inadequacy of a recitation only for the individual to whom it is ostensibly addressed, it is apparent to all the class that the teacher approves or disapproves of or agrees or disagrees with the performance given by the designated pupil.

C. METHOD

1. Sample

Thirty-one pupils (11 visible, 11 average, and nine invisible) were identified in 12 fifth-grade and sixth-grade classrooms. Mean arithmetic and sociometric scores for the three subsamples are given in Table 1.

TABLE 1
MEAN SCORES ON ARITHMETIC REASONING AND SOCIOMETRIC RATINGS

Type of pupil	N	Arithmetic reasoning	Sociometric nominations
Visible	11	15.75	16.92
Invisible	9	16.00	1.10
Average	11	9.64	1.46
Total	31		

2. Procedure

The authors developed an observational schedule designed to yield data pertinent to the hypotheses. This schedule contained two major categories: pupil-initiated interaction and teacher-initiated interaction. Subcategories under each of the major headings allowed the recording of the type of feedback given by the teacher: positive feedback (i.e., approval or agreement), neutral feedback, and negative feedback (i.e., disagreement or disapproval).

In addition, the pupil-initiated interaction category contained a subcategory for unsuccessful attempts subdivided into (a) withdrawn attempts and (b) ignored attempts. The observer made a tally in the appropriate subcategory of the schedule each time one of the pupils attempted to participate in the class discussion or was asked to do so by the teacher. Pilot runs with the schedule in its final form (but prior to the collection of data reported in this paper) yielded an interobserver agreement of 85 per cent.

Data were collected late in the autumn of 1963. The teachers of the 12 classes were informed that their arithmetic classes would be observed on four occasions—twice by each of the investigators. Data collection proceeded in two phases. On the occasion of the first period of observation, the arithmetic and sociometric tests were given, a schedule of observations was worked out, and the teacher was asked to prepare a seating chart to be used by the observers on their subsequent visits to the classroom. One restriction was placed upon the teachers' behavior. Teachers were asked to conduct recitations or class discussions during the periods that the observations were to be made rather than to allow pupils to work individually at their desks. Except for that limitation, the teachers were encouraged to behave as naturally as possible and to proceed with the regular arithmetic program as if no observer were present. No particulars about the purpose of the study were given to the teachers. The four observations constituted the second phase of data collection.

D. RESULTS

Based on the four observations, mean scores were computed for each category of behavior for each pupil. Results were combined across all classrooms. The outcomes of the tests of the several hypotheses are reported below.

Hypothesis No. 1 was that the mean number of interactions between the teacher and a visible pupil is significantly greater than the mean number of interactions between the teacher and invisible pupils and between the teacher and average pupils. The means for the three groups of pupils are 3.30 (for visible pupils), 3.67 (for invisible pupils), and 3.20 (for average pupils). These values are not significantly different from each other; so Hypothesis No. 1 cannot be accepted.

Hypothesis No. 2 was that there is a significant difference in the mean number of pupil-initiated interactions among visible, invisible, and average pupils; and that the difference favors visible pupils. Mean values are 2.18 (for visible pupils), 1.94 (for invisible pupils), and .86 (for average pupils). These differences are significant beyond the .001 level ($F = 11.38$; $df =$

2, 28). Visible and invisible pupils do not differ significantly from each other, but both of them differ significantly from average pupils.

Hypothesis No. 3 was that visible pupils attempt interaction with the teacher more frequently than do either invisible pupils or average pupils. Visible pupils attempted interaction 11.27 times each observational period; invisible pupils, 10.84 times; average pupils, 5.56 times. These means are significantly different at the .025 level ($F = 4.67$; $df = 2, 28$), a result attributable primarily to the difference between average pupils and each of the other types of pupils.

Hypothesis No. 4 was that the greatest frequency of withdrawn attempts occurs among invisible pupils. Mean values are 1.16 (visible pupils), 0.43 (invisible pupils), and 0.61 (average pupils), and the groups do not differ significantly from each other.

Hypothesis No. 5 was that attempts by visible pupils to interact with the teacher are less frequently ignored than are the attempts of other pupils. The means are 7.91 (for visible pupils), 8.58 (invisible pupils), and 4.09 (average pupils). It can be seen that visible and invisible pupils fare much alike; both types are ignored significantly more frequently than are average pupils ($F = 3.97$; $df = 2, 28$; $p < .05$). The hypothesis that invisible pupils are ignored more frequently than visible pupils is not supported.

Neither Hypothesis 6a (that visible pupils receive more positive feedback than do other pupils) nor Hypothesis 6b (that visible pupils receive less negative feedback than do average or invisible pupils) is supported. The means imply, however, that teachers provide positive feedback more often than negative. For positive feedback, the means are 1.93 (visible pupils), 2.06 (invisible pupils), and 1.37 (average pupils). For negative feedback, the means are 0.25 (visible pupils), 0.68 (invisible pupils), and 0.84 (average pupils).

E. DISCUSSION

The basic hypotheses of this study were (a) that interaction between pupil and teacher is an important source of information for pupils to use in forming estimates of the academic ability of each pupil and (b) that the pattern of interaction for invisible pupils is similar to that for average pupils whom they resemble sociometrically rather than to that for visible pupils whom they resemble in achievement.

Results of the investigation raise serious doubts about the validity of each assumption. If we divide the results into those (a) that pertain to interaction *per se* and (b) those that pertain to attempts at interaction, two implications

emerge. The pupils in our sample do not differ in the average number of interactions with the teacher or in the feedback they receive from the teacher. The teachers appear to be remarkably consistent, at least over relatively brief intervals, in distributing interactions equally among pupils and in evaluating pupil responses. Some pupils (the visible and invisible) initiate interaction more frequently than others (the average), but teachers tend to compensate for this difference by initiating interaction more frequently with the average pupil than with the visible or invisible pupil (means: 2.34, 1.73, and 1.12).

We cannot generalize the foregoing conclusions, but we feel that teachers possess an "automatic interaction counter" that, with relatively little error, guides them to an equal distribution of teacher-pupil interaction. Further, teachers seem to sense the need to provide positive feedback, but we cannot say the feedback is provided by the teacher assigning (for recitation purposes) the easier tasks to the less able pupils or by reshaping inadequate responses to merit reward. Further investigation of the strategies and their consequences for pupil learning seems to the authors an important and intriguing problem for educational psychology.

Our general hypothesis that visible and invisible pupils experience different patterns of interaction with the teacher receives little if any support. When differences occur, the result is always the same. Visible and invisible pupils behave similarly, but differently from average pupils. Except for the frequency of withdrawn attempts, the differences occur systematically for behavior under pupil control, but not for behavior under teacher control. Teachers seem to behave in ways designed to obliterate the recognition and differential evaluation of individual differences insofar as that is possible. In the long run, the more able pupils are not allowed to dominate discussion to the exclusion of the average pupils nor do their contributions in the formal interaction that constitutes recitation receive favorable reactions from the teacher more often than do the responses of average pupils.

How, then, do pupils earn academic reputations? Several possibilities occur. One is that peer perceptions are crystallized in the early days or weeks of the existence of a classroom group and are formed on the basis of only a few instances of behavior.

Another hypothesis is that the academic status of pupils is related not to frequency of interaction but to the content of interaction. The data reported in this paper reflect only the frequency of interactions and provide a basis for only a gross judgment (positive or negative) of the teacher's responses. Examination of the contents of the interaction might reflect among the three pupil types various differences that remained undifferentiated in our analysis.

If one could estimate the relative difficulty of the problems set or the questions asked by the teacher, subtle differences among the pupils might be reflected. Perhaps only the most able pupils feel competent to cope with very difficult problems and, though they do not participate more often than do others (because of limitations imposed by the teacher), the pupils take account of qualitative differences in recitation. Analyses of a comparable kind could be made of the teacher's evaluations of pupil responses. It may be that pupils discriminate (although our observation schedule did not) between teacher statements that "let the pupil down easily" and those that mark recognition of an adequate academic performance.

Visibility seems to be a pervasive characteristic of the individual. The visible pupil is not only seen by many of his classmates as an able arithmetic student, but is also widely chosen as a friend. The invisible pupil is not; he is not disliked by his classmates, but he does not appear to be salient for them. Inquiry into the psychological and perhaps the physical characteristics of the invisible pupil may be a promising line of attack in the effort to understand why invisible pupils are invisible.

As found in the 12 classrooms of this study, formal teacher-pupil interaction appears to be structured so as to make it an unlikely vehicle for altering peer perceptions of the invisible child.

F. SUMMARY

Thirty-one pupils (identified as visible, invisible, or average by sociometric ability ratings assigned by their classmates) were observed on four occasions in their arithmetic classes. Visible pupils and invisible pupils were high in arithmetic achievement, but differed in the extent to which peers recognized that ability. Average pupils were average in arithmetic achievement and in sociometric ratings. The investigators assumed that teacher-pupil interaction was a basis for the development of differential perceptions of pupils by their peers. Hypotheses were that interaction patterns for teachers with invisible pupils resemble those of teachers with average pupils, but are different from those for teachers with visible pupils. Pupils were found to differ in their attempts to initiate interaction with the teacher. Visible pupils and invisible pupils do not differ from each other, but both attempt interaction with greater frequency than do average pupils. Total frequency of interaction and the proportion of positive and negative feedback—that is, the variables under the teacher's control—do not differ among the three types of pupils. Results are interpreted as implying that teachers behave in formal interaction in ways

designed to minimize the appearance of individual differences in arithmetic ability among pupils of the three types studied.

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AGE DIFFERENCES IN VERBAL ASSOCIATIONS*¹

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A. INTRODUCTION

In view of the importance of verbal skills, it is not surprising that increasing attention is being given to age differences in verbal behavior. While the subject of differences in verbal behavior in the adult years has not been thoroughly studied, several facts can be stated with some assurance (7). In general, the number of words known by adults, as measured by a synonym-vocabulary test, rises throughout most of the life span; thus the amount of verbal information that is stored in a relatively passive manner rises with age (2, 9). Riegel has pointed out that the verbal performance of older persons relative to that of younger persons depends upon the nature of the task: e.g., they do better on a synonym test than upon tests that require logical selections (8). The way in which such stored information can be utilized depends upon functions such as association latency and the set of the individual in searching his verbal store, as well as the way in which the stored information is organized (10).

Results have also indicated a decline with age in verbal fluency or in the number of words associated in a fixed period: e.g., the number of words beginning with a particular letter of the alphabet (1, 11, 12). Speed of both written and spoken word associations seems to decline with age (4). Since this is parallel with the rise in number of words known, it suggests that a large number of known words leads to interference; hence, to an apparent slowing of association time. Thus, while a large number of words leads to a higher probability of locating rapidly a relevant word, it may also lead to some slowness because of a greater number of choices. Furthermore, those words already associated tend to evoke further associations with other words not necessarily relevant to a present task and as such must be rejected or inhibited.

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¹ The study was conducted at the Section on Aging, National Institute of Mental Health, Bethesda, Maryland. During the analysis, the senior author held a Summer Faculty Research Fellowship at The University of Michigan. The authors are greatly indebted to the institutions as well as to Dr. Ruth M. Riegel and Mr. J. S. Robbin for their valuable help during the collection and analysis of the data.

Such considerations lead to a picture of age differences in verbal behavior as an outcome of (a) an intrinsic speed of search for associations and (b) the number of words known, which both facilitates and detracts from rapid verbal behavior. Some evidence has been presented that there might be a general speed factor involving both rapidity of simple responses as well as rapidity in making more complex verbal discriminations and choices (3).

The purpose of the present study is, first, to analyze the nature of age differences in the number of verbal responses given and the latencies of responses to stimuli with different numbers of possible associations. For the interpretation of the results, two intervening speed factors had to be postulated: emergence time (ET) and selection time (ST). The second purpose is to analyze the differences between the observed variability in verbal associations and the degree of restriction imposed by the particular stimuli. Again, consideration was given to differences between the age groups as well as between discrete tests and continuous tests. Third, age differences in changes in verbal behavior over the four consecutive blocks of 10 test items are analyzed.

B. PROCEDURES

1. *Subjects*

Two tests of syllable associations were given to 30 young Ss and 23 elderly Ss. The young group consisted of 15 men and 15 women from 18 to 33 years of age. Their mean education was 14.0 years. Thirteen were religious volunteers for research in the Clinical Center of the National Institute of Health; 11 were students at the American University, Washington, D.C.; the remainder were employees at the National Institute of Mental Health. The elderly group consisted of 11 women and 12 men from 60 to 80 years of age. Their mean education was 13.2 years. All these Ss were volunteers from the community and were either retired government employees or were spouses of retired employees.

2. *Methods*

In the first test, discrete-syllable associations, 40 syllables were given individually to Ss.

Here, I have 40 cards. Each has a syllable on it. I will read the syllables to you and I will show you the cards. It will be your task to *name a word which begins with the same syllable as shown on the card*. For example, to the syllable CAN you may say: CAN-DY, CAN-CEL, CAN-CER, CAN-YON, CAN-NON, or CAN-DLE.

The stimuli are first syllables of words, listed in the Thorndike-Lorge

count (13). Thirteen of the syllables consist of two letters; 15, of three; 10, of four; and two, of five. The syllables were presented in random order. As a preliminary trial, the syllable "DE" was used. The test session was recorded on tape, from which the responses as well as the response latencies have been transcribed.

In the second test, continuous-syllable association, the same 40 items were given in the same random order.

For our next problem we have 40 syllables again. It will be your task to *write as many words as you can think of, which begin with the same syllables as shown in the list*. For example, to the syllable CAN you may write: CAN-DY, CAN-CEL, CAN-CER, CAN-NON, or CAN-DLE. Write the whole word. I will give you 45 seconds for each syllable.

The syllables were typewritten, with sufficient space for the responses. As a preliminary trial, the syllable "DE" was used. The second test was given two days after the first. For a few Ss, both tests were separated by about two hours during which the Ss performed the "psychomet" experiments described elsewhere (3).

C. RESULTS AND DISCUSSION

1. *Speed of Responding*

Response latency and number of responses given during 45 seconds are the primary measures on the tests of discrete and continuous associations respectively. Figures 1 and 2 show the results. For continuous associations, the mean number of responses decreases with an increasing number of letters that constitute a stimulus syllable. This result is not surprising because an increase in the number of letters implies an increase in the amount of restriction imposed. Stated differently, the larger the number of letters per syllable the smaller is the number of alternative responses available. The degree of restriction has a differential effect upon age. Older Ss give fewer responses than younger Ss, but the differences between the age groups are larger for medium and low degrees of response restrictions (three or two letters) than for a high degree (four or more letters). These results have been confirmed by variance analysis, as shown in Table 1.

To analyze more precisely the amount of restriction imposed, the number of alternatives listed in Part I of the Thorndike-Lorge count ($\log \text{NoAlt}$) was determined by counting all the words that begin with each of the particular syllables used. As shown in Figure 3, the mean logarithms of the number of alternatives decrease in precisely the same manner as the mean

number of responses given by Ss. The correlation between the two variables is .94 for young Ss as well as for old Ss.

The response latencies of the discrete test, shown in Figure 2, are more difficult to interpret. The data appear to indicate that *too many* responses are available in case of the two-letter syllables; therefore the response latencies

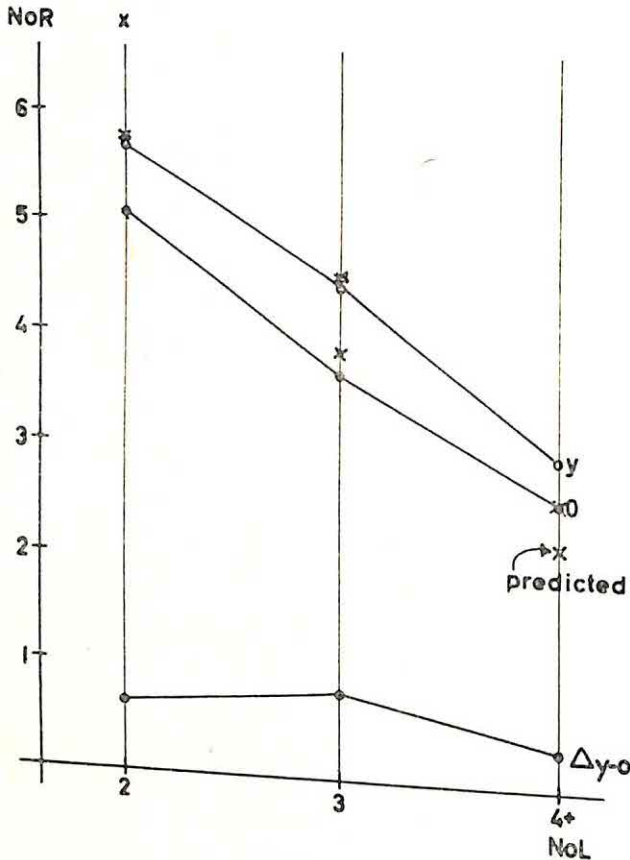


FIGURE 1
NUMBER OF RESPONSES (NoR) BY OLD SUBJECTS (O) AND YOUNG SUBJECTS (Y)
PLOTTED AGAINST NUMBER OF LETTERS PER STIMULI (NoL)

are relatively high as compared with those for the three-letter stimuli for which stimuli the degree of restriction seems to be optimal and the number of responses available seems to be *just right*. The latencies increase again with further restrictions under which *too few* alternative responses are available to Ss. While such an interpretation holds up well for both age groups, a

differential effect can also be observed. The increasing degree of restriction delays in particular the responses of older Ss. According to Table 2 the differences in age and response restrictions, as well as their interaction, are significant.

For a more comprehensive interpretation of the results, we regard the

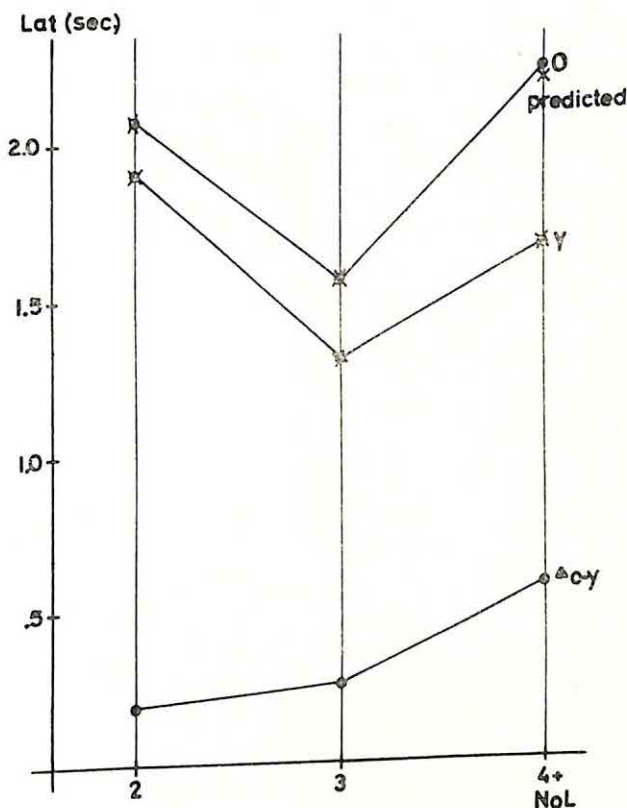


FIGURE 2
RESPONSE LATENCIES (*Lat*) OF OLD SUBJECTS (O) AND YOUNG SUBJECTS (Y)
PLOTTED AGAINST NUMBER OF LETTERS PER STIMULI (*NoL*)

observed latencies as composed of two intervening speed factors that counteract each other. We call these factors emergence time (ET) and selection time (ST). In particular, emergence time (ET) should be inversely related to the logarithm of alternative responses. In other words, the more responses possible the shorter the time for the emergence of any one of them:

$$ET = \frac{C_1}{\text{LogNoAlt}} \quad [1]$$

Selection time (ST) should be directly related to the number of alternative responses. Imposing the most severe condition, we maintain that selection time is directly proportional to the squared logarithm of the number of alternatives. Thus, we imply that every possible response might conflict with or inhibit any other before it is verbalized:

$$ST = C_2(\text{logNoAlt})^2. \quad [2]$$

Adding both components and determining multiplicative constants we obtain

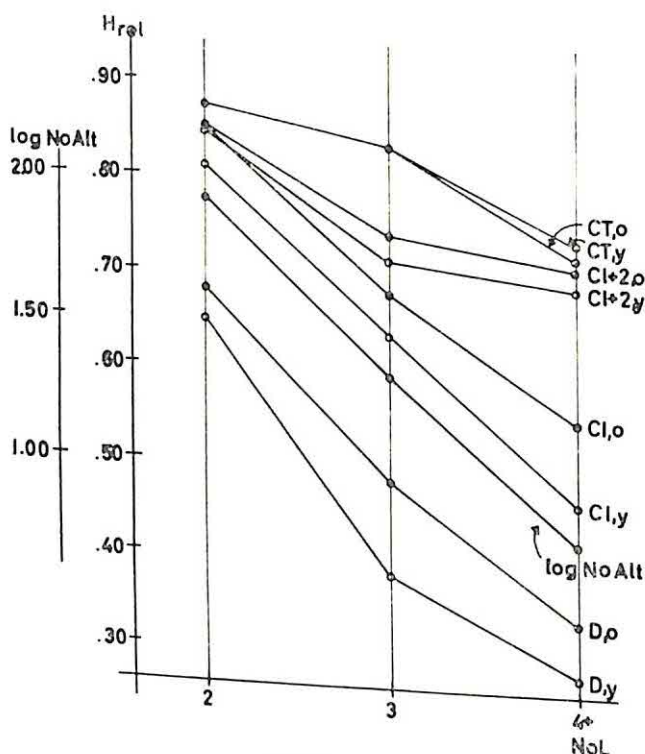


FIGURE 3
LOGARITHMS OF THE NUMBER OF ALTERNATIVES LISTED IN THE THORNDIKE-LORGE COUNT
($\log \text{NoAlt}$) AND RELATIVE ENTROPY OF RESPONSES (H_{rel}) BY OLD SUBJECTS (O)
AND YOUNG SUBJECTS (Y) PLOTTED AGAINST NUMBER OF LETTERS
PER STIMULI (NoL)
D = responses of the discrete task; C1 = first responses of the continuous task;
C1 + 2 = first two responses of the continuous task; CT = all responses of the

the following two equations for the mean response latencies (Lat) of young and old Ss :

$$Lat_y = \frac{1.08}{\log NoAlt} + .35(\log NoAlt)^2 \quad [3]$$

$$Lat_o = \frac{1.50}{\log NoAlt} + .34(\log NoAlt)^2 \quad [4]$$

As shown in Figure 2, our equations predict almost perfectly the observed response latencies. Differences between the predicted scores and the observed scores amount to less than seven msec. If F ratios are computed with the differences between the observed latencies and their overall means as nominator and the differences between the observed latencies and predicted latencies

TABLE 1
ANALYSIS OF VARIANCE FOR NUMBER OF RESPONSES IN CONTINUOUS-SYLLABLE
ASSOCIATION TEST

Source	SS	df	F	p
Between S	539.52	52		
A (Age)	63.79	1	6.84	.025
Error (6)	475.73	51		
Within S	1,220.94	583		
B (No. letters)	682.09	2	410.90	.001
C (Serial order)	81.92	3	31.75	.001
Interaction				
Age-by-letters	5.92	2	3.57	.05
Age-by-order	6.84	3	2.63	.05
Letter-by-order	35.18	6	9.45	.001
Age-by-letters-by-order	2.71	6	.73	NS
Error (W)	406.28	561		
Error ₁ (W)	84.29	102		
Error ₂ (W)	130.95	153		
Error ₃ (W)	191.04	306		
Total	1,760.46	635		

as denominator, a high degree of significance is found for both the young and the old group ($p < .01$).

Our predictions are remarkable because no additive constants are used. The multiplicative constants are averages of figures that have been determined by solving the three equations for the two-letter, three-letter, and four-letter stimuli in all possible pair combinations. The differential increase in latencies with age has to be explained in terms of an increase in emergence rather than in selection time. The weights of the latter are almost identical, while the

TABLE 2
ANALYSIS OF VARIANCE FOR RESPONSE LATENCIES IN DISCRETE-SYLLABLE
ASSOCIATION TEST

Source	<i>SS</i>	<i>df</i>	<i>F</i>	<i>p</i>
Between <i>S</i>	218.25	52		
A (Age)	30.21	1		
Error (b)	188.04	51	8.19	.01
Within <i>S</i>	681.23	583		
B (No. letters)	46.30	2	23.15	.001
C (Serial order)	4.43	3	1.70	NS
Interaction				
Age-by-letters	7.65	2	3.83	.025
Age-by-order	10.02	3	3.84	.01
Letters-by-order	39.49	6	6.15	.001
Age-by-letters-by-order	10.04	6	1.56	NS
Error (W)	563.31	561		
Error ₁ (W)	101.74	102		
Error ₂ (W)	132.96	153		
Error ₃ (W)	328.62	306		
Total	899.48	635		

weight assigned to the emergence time is larger for the older *Ss* than for the younger *Ss*.

The same reasoning might be applied for an analysis of the number of responses emitted in the continuous test. Dividing the total time per item (45 seconds) by the number of responses (*NoR*), we estimate the average time interval (latency) between successive responses as follows:

$$Lat_y = \frac{45}{NoR} = \frac{10.78}{\log NoAlt} + .72(\log NoAlt)^2 \quad [5]$$

$$Lat_o = \frac{45}{NoR} = \frac{12.21}{\log NoAlt} + .92(\log NoAlt)^2 \quad [6]$$

The predictions shown in Figure 1 do not correspond very well with the trend of the data and are significant only at the .05 level for the young *Ss* and are nonsignificant for the old *Ss*. For an interpretation we have to take the following difficulties into consideration.

Because *S* is not restricted to a single response and might give any appropriate word as soon as it occurs to him, the effect of the selection speed seems of minor importance for his performance; i.e., the interference between different responses can be regarded as negligible, and emergence time determines primarily the speed of his output. This conclusion is clearly supported by our results. While, for the predictions of the discrete associations, the

ratios of the first multiplicative constant to the second are about 3:1 for the young Ss and 4:1 for the old Ss, these ratios increase to about 15:1 and 13:1 for the continuous associations. Generally, the latencies of the continuous associations (i.e., the time intervals between successive responses) are much higher than for the discrete associations. Apparently the responses are not equally spaced within the 45 seconds of each test item, but the time intervals increase rapidly after the first response.

Because emergence time is the main determinant of the number of continuous associations and because emergence time is also found to explain the high latencies of old Ss on the discrete task, the lower number of continuous associations is consistent with the wider and flatter response distribution for older Ss as compared with that for younger Ss. As will be discussed in reference to Figure 3, such differences in the response distributions imply that older Ss should produce more words on the continuous task than younger Ss but, apparently, this prediction is outweighed by the changes in emergence time. Such a specific prediction, however, is hardly warranted because we do not at all insist that changes in emergence and selection time, as well as differences in the size of the response repertoires, are the only characteristics of the aging process. Undoubtedly, a general decline in speed of functioning does occur and is revealed by comparisons of the weights assigned to the foregoing equations, as well as by the results given in Figures 1 or 5 and Table 1. In our present discussion, the *relative* importance of the emergence and selection factors for the performance of the two tasks by two age groups has been our main concern.

Such a general speed factor might also explain our failure to predict the performances on the continuous task. In particular, more time is required for writing five or six responses to two-letter stimuli than for writing three responses to four-letter stimuli. If we could have eliminated the differences in writing time the differences between the predicted and the observed latencies would have been diminished. However, for this purpose we had to introduce a third constant, an additive constant, proportional to the number of responses written. Such constants would have allowed for perfect predictions, but would have made the solutions trivial because many equations that include two multiplicative and one additive constant would serve such a purpose.

Because of interactions between the number of letters, the logarithm of the number of alternatives, and the age of Ss, our predictions apply only when the number of letters per stimuli is held constant; i.e., the latencies can be

predicted only if the number of letters per stimuli has been specified. Our data do not allow for a complete analysis of the interactions.

To what extent are extrapolations below the two-letter stimuli and above the four-letter stimuli valid? If we had used *any* letter sequence regardless of whether it formed a complete syllable or not, lower latencies for one-letter stimuli than for two-letter stimuli might have been found. The same might be true for those long sequences that approach closely the total lengths of real words: i.e., stimuli to which only one or two letters need to be added. In other words, systematic investigations with letter sequences that do not necessarily represent complete and single syllables might reveal latencies that follow an upward-downward-upward-downward trend. At the present time, such investigations are not available.

2. Response Distributions

As shown in Figure 3, empirical estimates of the response distributions were compared with the mean $\log NoAlt$ obtained from the Thorndike-Lorge count. As the most appropriate measure, relative entropies were computed separately for the discrete-syllable associations (D) as well as for the first response ($C1$), the first two responses ($C1 + 2$), and all the responses (CT) given in the continuous test. Other measures (such as the number of different responses and the proportions of primary and of single responses) were also tried but did not yield different results. The measure of relative entropy that utilizes most completely the information provided by our data was computed according to the formula:

$$H_{rel} = \frac{-\sum p \log p}{H_{max}} \quad [7]$$

In the foregoing formula, p denotes the proportions of the various responses. H_{max} is an estimate of maximum uncertainty in responding and is obtained on the assumption that all responses are emitted with equal probabilities. This estimate of H_{max} is slightly less conservative than the less realistic assumption that each S responds completely in his own way; i.e., that there are as many different responses as there are S s in the groups.

Figure 3 shows the following: First, the empirical indices of the response distributions (H_{rel}) are similar to the estimates from the Thorndike-Lorge count ($\log NoAlt$). This is particularly true for the responses given in the discrete-syllable test (D) as well as for the first responses of the continuous-syllable test ($C1$). In computing $\log NoAlt$, we take into account only the number of

words listed—not their frequencies of occurrence. This is not true for H_{rel} and, accordingly, the deviation of H_{rel} for all the responses of the continuous test (CT) from the $\log NoAlt$ might have been smaller if the frequency of the words listed by Thorndike and Lorge had been taken into consideration. Apparently, Ss' response tendencies for the discrete-syllable test (D) and the beginning of the continuous-syllable test (C1) are determined by the range of available alternatives. The relative frequencies of words become important only during the later periods of continuous associations. This result is congruent with earlier findings on perception and set in young and old Ss (10).

Second, H_{rel} is much lower for the discrete test than for the continuous test. Thus Ss' response tendencies are more restricted under the greater time stress of the discrete test and under the condition that only one response was to be given orally rather than that many responses were to be written. Stated differently, the distribution of the responses is less random, and the prediction of the responses (given the stimulus) is better for the discrete test than for the continuous test. One should remember that the continuous test always followed the discrete test but, according to available evidence, practice decreases response variability rather than increases it (5, 6).

Third, the distributions of the first responses of the continuous test (C1) are closer to the $\log NoAlt$ and to the distributions of the responses in the discrete test (D) than are the first two responses ($C1 + 2$) or the total set of all responses (CT). The strong increase in relative entropy between the C1 and $C1 + 2$ responses to four-letter stimuli indicates that Ss begin to exhaust their response repertoires. On the average, young and old Ss give only a total of three responses to four-letter stimuli. For the same reason, relative entropy does not increase much further after the first two responses ($C1 + 2$) have been given.

Fourth, age differences are particularly marked for the discrete task (D) and for the first responses of the continuous task (C1). Throughout, the response distributions of the older Ss are flatter than those of the younger Ss. This fact might explain the slightly higher negative correlation between the word frequencies of the total unit (made up of the stimulus and response syllables) and the latencies for the older Ss ($-.60$) in contrast to those for the younger Ss ($-.55$). Both correlations differ significantly from zero and support the Thumb-Marbe law for our type of task. The differences in the response distributions disappear with continued responding to the items, as shown in the analyses of the first two responses ($C1 + 2$) and all responses (CT) of the continuous test. It is tempting to say that young Ss "age" more rapidly

during performance than old *Ss* by giving relatively more different words per time unit the longer they respond to an item. Although the implications of such an interpretation cannot be elaborated, the changes in the average response distributions of young and old *S* shown in Figure 4 support this point.

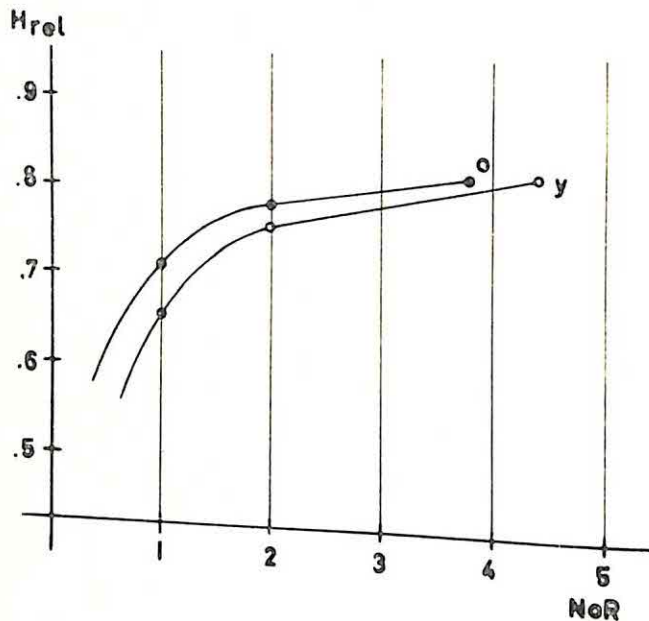


FIGURE 4
RELATIVE ENTROPY OF RESPONSES (H_{rel}) PLOTTED AGAINST THE NUMBER OF RESPONSES (NoR) GIVEN BY OLD SUBJECTS (O) AND YOUNG SUBJECTS (Y)

3. Order of Items

Results of regrouping the data according to the order of stimulus presentation are shown in Figures 5, 6, and 7. While the latencies of the young *Ss* remain almost constant throughout the test, there is a marked decline in latencies among the old *Ss* until they finally reach the speed level of the young *Ss*. The number of responses given in the continuous test first shows a downward trend and then an upward trend for both age groups (the age differences becoming larger for the last 10 items only). According to Tables 1 and 2, serial order has a significant effect upon the number of responses of the continuous test but not upon the response latencies of the discrete test. Apparently, the stability in the latencies of the young *Ss* confounds the changes

among the old Ss. Both the significant interaction term of Table 2 and the results of two analyses of the separated age groups support this interpretation. In the latter case serial order is significant for the old Ss ($p < .05$) but not for the young Ss.

The decrease in response latencies among old Ss suggests changes in "task

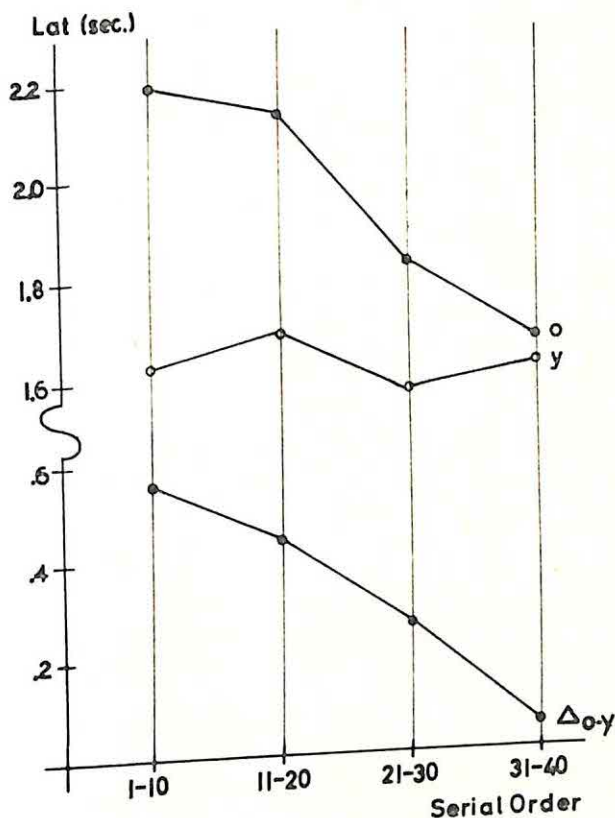


FIGURE 5
RESPONSE LATENCIES (*Lat*) OF OLD SUBJECTS (O) AND YOUNG SUBJECTS (Y)
PLOTTED AGAINST SERIAL ORDER OF STIMULI

attitude" or "implicit set." The results shown in Figure 7 suggest such an interpretation, indicating that changes in response latencies are correlated with changes in the distributions of the discrete responses. The response distributions of the discrete test (D) reveal a marked decrease in random-

ness for old Ss, while young Ss show first a downward trend and then an upward trend.

The irregularities in the results observed for the young Ss on the discrete test, as well as for both age groups under all the other conditions (i.e., for C1, C1 + 2, and CT), make our interpretation more difficult. All these

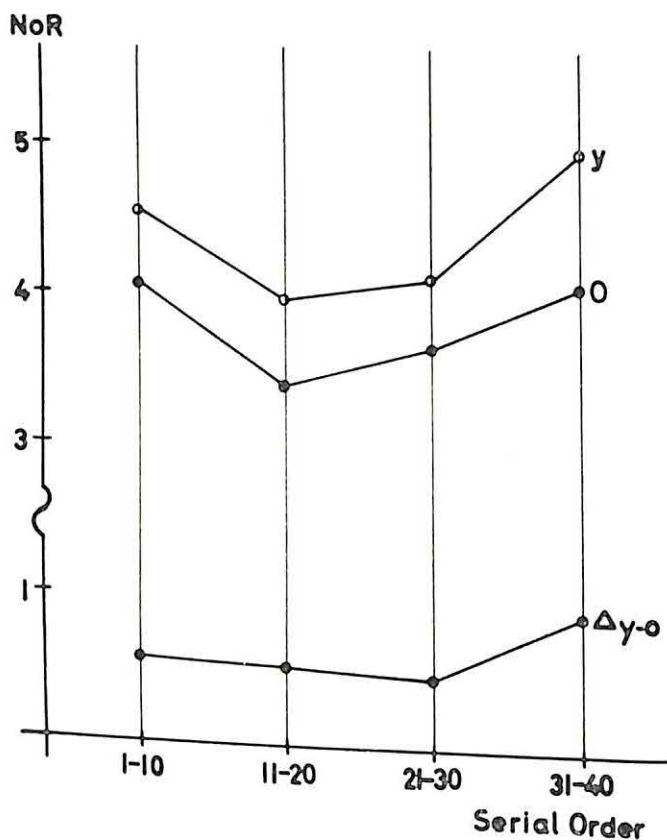


FIGURE 6
NUMBER OF RESPONSES (NoR) BY OLD SUBJECTS (O) AND YOUNG SUBJECTS (Y)
PLOTTED AGAINST SERIAL ORDER OF STIMULI

response distributions yield higher scores for the first group and the last group than for the third group and the second group of items. Because the mean numbers of alternatives listed in the Thorndike-Lorge count are not evenly distributed between the four groups of items either, we failed in randomizing the stimuli. In other words, the restriction of the responses is

greater and the mean $\log NoAlt$ are lower for the second group and the third group of items than for the first group and the last group.

The logarithms of the number of alternatives, as the most "objective" measure, could be used for correcting (i.e., for levelling out) differences in response availability between the items. If such corrections are made, differences in response distributions between the four groups of items disappear

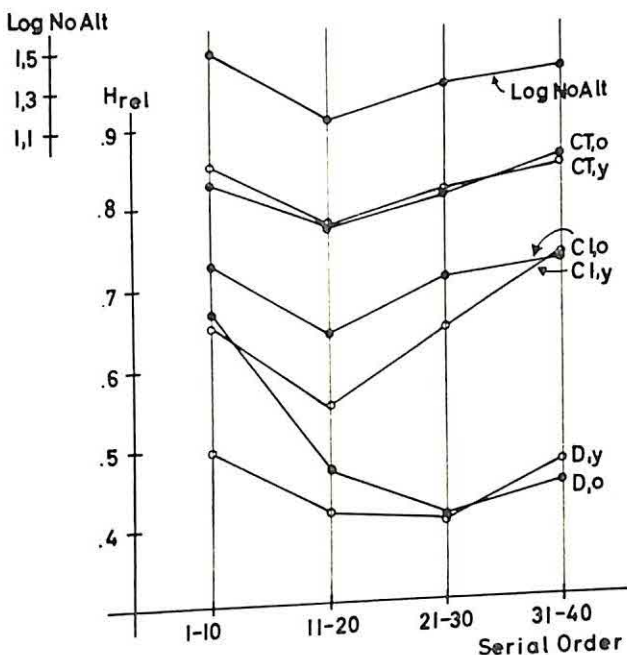


FIGURE 7

LOGARITHMS OF THE NUMBER OF ALTERNATIVES LISTED IN THE THORNDIKE-LORGE COUNT ($\log NoAlt$) AND RELATIVE ENTROPY OF RESPONSES (H_{rel}) BY OLD SUBJECTS (O) AND YOUNG SUBJECTS (Y) PLOTTED AGAINST SERIAL ORDER OF STIMULI. D = responses of discrete task; C1 = first responses of the continuous task; CT = all responses of the continuous task. For simplification of the drawing the relative-entropy values of the first two responses (C1 + 2) have not been plotted. They lie halfway between the values for C1 and CT.

except for the decrease observed on the discrete test for old Ss. It is this change in response distribution that should explain the change in the response latencies of old Ss on the same test.

To analyze these age differences statistically, all regression coefficients of the H_{rel} on $\log NoAlt$ have been computed. With exception of the discrete test

(D), none of the coefficients (C_1 , $C_1 + 2$, and CT) differ significantly between the age groups. The discrete test (D), however, shows a significant age difference ($p < .01$) and, thus, indicates a change in the approach to the task on part of the old Ss that explains the decrease in their response latencies. Instead of relying on their total response repertoire with all their idiosyncrasies, older Ss shift toward the use of a more restricted subset of responses that includes only the more frequently and commonly used words. The more older Ss do the foregoing, the faster they are able to react.

D. SUMMARY AND CONCLUSIONS

Two tests of syllable associations were given to 30 young Ss and 23 elderly Ss. In the first test, one word each had to be given as responses beginning with the particular stimulus syllables. The same 40 stimuli were used for the second test, but for each stimulus Ss had to write as many words as they could during 45 seconds. Latencies on the first test are related in a curvilinear manner to the number of letters per syllable, being shortest for three-letter stimuli. Number of responses on the second test decreases linearly with the number of letters per stimuli. All variables correlate highly with the number of alternatives listed in the Thorndike-Lorge count, as well as with various measures of response dispersion. Latencies are stable throughout the first test for young Ss, but decrease significantly for the older Ss. Older Ss seem to show a systematic change in their implicit set. On the basis of these findings the following conclusions were reached.

1. There is an optimum level of response restriction at which S functions fastest. This level is attained with three-letter stimuli. Both age groups have longer latencies at higher or lower levels: i.e., when too few responses or too many responses are possible. While the old Ss are slower than the young Ss, under all conditions their handicap is greatest under greatest response restrictions: i.e., in the case of four-letter stimuli.
2. The observed differences in latencies between different degrees of response restrictions and between the two age groups are explained by two intervening speed factors: emergence time of responses (ET) and selection time between alternative responses (ST). The first factor is regarded as inversely related to the logarithm of alternative response listed in the Thorndike-Lorge count; the latter, as directly related to the squared logarithm. Assuming additivity of the two speed factors, the observed latencies can be predicted with extreme accuracy when grouped according to the number of stimulus letters. No additive constants need to be used. The higher latencies of the old Ss are primarily attributable to a decrease in emergence speed.

3. On the average, the responses of older Ss are more randomly distributed; i.e., the distributions are flatter and wider than are those for young Ss. This is particularly true for the discrete test (D) and for the first responses on the continuous test (C1). The differences in randomness between the age groups become smaller with increasing length of the test. This is shown by comparison of relative entropies for the first two responses (C1 + 2) and for all responses of the continuous test (CT) with corresponding values for the first responses of the continuous test (C1) and of the discrete test (D).

4. When stimuli are grouped according to their order of presentation, the latencies of young Ss are relatively stable. Older Ss, however, increase their response speed throughout the test and finally reached the latency level of young Ss. This change in performance is closely related to a decrease in the randomness of responses among old Ss. Apparently older Ss change their implicit set or task orientation. By restricting their responses to the most common ones and by avoiding unique and original answers, they increase their speed during continued performance.

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COMPONENTS OF REACTION TIME IN RELATION TO AGE AND SEX*

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A. INTRODUCTION

In a recent examination of some of the antecedents of reaction time, especially as it related to the study of aging, three theories were explicated: nerve conduction theory, set theory, and bio-potential wave theory (2). The present study was concerned with nerve conduction and set theories, and, in addition, specific questions regarding the interaction between age and sex in relation to reaction time were investigated. Nerve conduction theory focuses upon segmenting total reaction time into component parts, and set theory attempts to explain variations in reaction time as functions of set or attention factors which may be manipulated experimentally.

Two studies bear most directly on the present one. Weiss (9) segmented reaction time into motor and premotor components and examined these components in relation to age and to other variables. This will be discussed later in relation to the present study. The second study involved the finding that elderly female Ss were quicker (shorter reaction time) than elderly males, while with younger controls the reverse was the case; young men were quicker than young women (3). It may be speculated that if, as many at least imply [e.g., (1, 8, 9)], reaction time is a reflection of central nervous system function, then the age-sex interaction in reaction time may have central nervous system implications. The finding that elderly women were quicker than elderly men was based upon Ss aged 61-80 years. It was indicated, however, that the elderly women were eight years younger than the men and this may have contributed to the results (3). In the present study, ages of men and women were adequately equated for the test of an age-sex interaction in reaction time.

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B. METHOD

1. *Subjects*

The Ss were 88 white men and women volunteers of two age groups. The elderly group comprised 44 Ss of the Duke Longitudinal study, the characteristics of whom were described by Busse (7, pp. 680-681). The total sample of elderly Ss comprised community residents from a wide socioeconomic range. The present subsample was selected on the basis of having completed 12 or more years of formal education, or the equivalent. There were 17 men aged 68 to 87 years (median = 78.0), and 27 women aged 69 to 84 years (median = 76.0). The respective median years of education were 17 and 15. The younger group comprised students, secretarial and clerical staff, housewives, and unemployed people recruited from the local employment agency. Ss volunteered to receive a nominal fee, to fulfill the requirements of a first course in psychology, or simply for the reason of contributing their time for research purposes. There were 29 men aged 19 to 32 years (median = 20.0), and 15 women aged 18 to 35 years (median = 20.0). The median years of education were 14 and 13 respectively.

2. *Procedure*

Reaction times were measured on each S individually with both regular series and irregular series. (In regular series the foreperiod or preparatory interval is constant within a block of trials, and in irregular series the preparatory interval is varied within a block of trials). Approximately twice as many Ss within each age and sex subgrouping experienced the irregular series first and the regular series second. In collecting the data, Ss were assigned to an equal counterbalanced arrangement of regular and irregular series; but afterward, when data were discarded in order to equate for age within the sex subgroupings, to maintain relatively homogeneous education levels among the subgroups, and to have records only of completed series, it worked out in the manner indicated. The appropriate data were discarded *before any analyses* were begun. The regular series were presented in quasi-counterbalanced arrangements of ascending and descending preparatory interval orders. (An ascending series is one in which the preparatory interval order is from a short duration of 0.5 seconds to a long duration of 15.0 seconds.)

The exact procedure may be found in a study by Botwinick and Thompson (5) in which most of the data of young Ss of the present study were analyzed for a different purpose. The important features of the procedure involved a warning signal of 0.5-second duration which came on approximately two

seconds after a telegraph response key was pressed. This was followed by the preparatory interval and then the stimulus which was terminated by the finger lift response. The stimulus was a 1000 cycle per second tone approximately 85 db measured at *S*'s position 5-6 feet from the sound source speaker. The warning signal which preceded the tone stimulus was a 400 cycle per second tone of approximately 75 db. Four preparatory intervals, 0.5, 3.0, 6.0, and 15.0 seconds, were used in both regular and irregular series.

Simultaneously with the reaction time measurements, electromyograms (EMGs) were recorded from the *extensor digitorum communis* of the responding forearm. The potentials were amplified and recorded with a Grass, Model III, eight channel EEG. EMGs were recorded for the middle reaction time trials of each preparatory interval. There were 40 EMGs in regular series (10 of each preparatory interval), and 42 EMGs in irregular series (9-11 of each preparatory interval).

For each reaction time, the ink record was analyzed manually by measuring with a millimeter scale the distance between the point on the EMG tracing where the stimulus began and the point of first increased muscle firing. This was the premotor time. Reaction time was the measured distance between stimulus onset and finger lift response. The premotor time measurement was subtracted from the reaction time measurement to give the motor time. For each *S* the medians of reaction time, premotor time, and motor time were computed independently for each preparatory interval within each of the two series.

C. RESULTS

Variance analyses by the unweighted means approach for unequal cell frequencies (10, pp. 222-224) were carried out with the reaction time data, and with the data of premotor and motor components of reaction time. These analyses were of both regular and irregular series and were based upon the median values of the individual *Ss*. The means of these median reaction times, premotor times, and motor times may be seen in Figure 1. The means of motor time are of pooled sex groups within each of the two age groups. The reason for this was that group mean differences of motor time were so small that the figure would be unclear if the motor times were presented for each of the four subgroups. For example, the range of reaction times in Figure 1 was from .193 to .407 seconds, the range of premotor times was from .152 to .346 seconds, and the range of motor times from .032 to .059 seconds. The analyses of the data, however, were based on the subgroups unpooled.

The main effect variables in these analyses were age of *S*, sex of *S*, and the

preparatory interval. In Table 1 the contribution of these variables and their interactions may be compared for reaction time and for components of reaction time in regular and in irregular series. In each of the six variance analyses, the two elderly age groups were statistically slower than their younger controls ($p < .01$). That is, motor time, premotor time, and reaction time were slowed with advanced age when Ss responded to stimuli in both regular and irregular series.

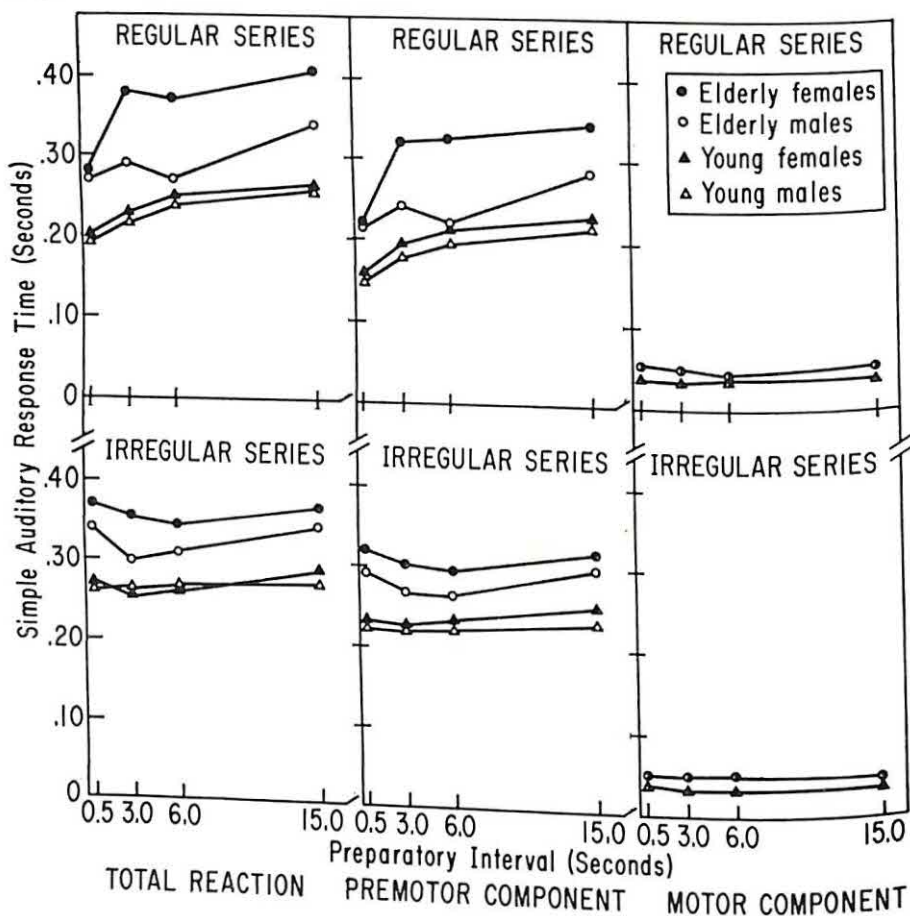


FIGURE 1
SIMPLE AUDITORY REACTION TIME AS A FUNCTION OF THE PREPARATORY
INTERVAL FOR FOUR CLASSES OF SUBJECTS

Reaction time was segmented into two component parts: premotor time and motor time. Mean reaction time and mean components of reaction time are seen in relation to the preparatory interval within irregular and regular series. Mean motor times are of pooled male and female subgroups; other means are of males and female Ss separately within an age group.

TABLE 1
VARIANCE ANALYSES OF RT AND COMPONENTS OF RT
OF REGULAR AND IRREGULAR SERIES

Source	df	F*					
		RT ^a		PMT ^a		MT ^a	
		Reg.	Irreg.	Reg.	Irreg.	Reg.	Irreg.
Between Ss	87	9.52**	19.49**	9.42**	19.09**	8.10**	19.78**
Age (A)	1	22.21**	14.25**	15.42**	10.13**	12.76**	13.72**
Sex (S)	1	3.72	1.11	3.28	1.10	.00	.08
A × S	1	2.26	.67	1.64	.15	1.18	2.33
Error: (M ²) ^b	84	(31.72)	(30.80)	(32.65)	(31.91)	(1.14)	(.90)
Within Ss: (M ²) ^b	264	(4.30)	(1.82)	(4.16)	(1.83)	(.16)	(.05)
Prep. Int. (PI) ^a	3	29.70**	7.85**	32.98**	4.72**	3.61*	.86
A × PI	3	2.08	1.12	1.53	1.29	3.26*	.77
S × PI	3	2.95*	.25	3.58*	.01	.30	1.06
A × S × PI	3	2.59	1.82	2.47	.33	1.11	.98
Error: (M ²) ^b	252	(3.12)	(1.68)	(2.94)	(1.78)	(.15)	(.05)
Total	351						

Note: The *F*-ratio may not equal exactly the ratio of the respective mean square to the error terms, due to rounding off to 2 decimal places. Differences are only in the decimals.

^a Reaction time (RT) was fractionated into two component parts: premotor time (PMT) and motor time (MT). RT was measured in relation to the variation of the preparatory interval (PI) which was the period of time between the warning signal and the stimulus.

^b Analyses were carried out with reaction time, premotor time, and motor time in milliseconds. Thus, mean squares were divided by 1000 in this table.

* Significant at .05 level.

** Significant at .01 level.

In each of the six analyses, except one, response time was related to the preparatory interval ($p < .01-.05$). The one exception was motor time in irregular series ($p > .05$). Statistically significant interactions were found only with regular series. Sex of *S* interacted with preparatory interval in regard to reaction time and premotor time ($p < .05$), the nature of which may be seen in Figure 1. There was a statistically significant interaction between age and preparatory interval with motor time ($p < .05$). Elderly and young *Ss* were more similar in motor time with the 6.0-second preparatory interval than with preparatory intervals of longer and shorter duration.

It may be seen in Figure 1 that the premotor components constituted an appreciable per cent of total reaction time. This was the case for each age and sex group of both regular and irregular series. Per cents (ratios) of premotor to reaction time ranged from 79 to 90 when computed with the means of each of the four subgroups (two ages and two sexes) in relation to the four preparatory intervals within both the regular and irregular series. The mean of these 32 per cents was 84.4. The comparable per cents of motor time to reaction time ranged from 12 to 21 with a mean of 15.5.

D. DISCUSSION

Elderly *Ss* were slower than young *Ss* in both premotor time and motor time, and, therefore, reaction time. In both age groups, the premotor component constituted approximately 84 per cent of total reaction time, and the motor component constituted the remaining 16 per cent. In the present study, the interactions between age and preparatory interval with respect to reaction time were not statistically significant, $p > .05$. These relations, however, have been shown in previous studies to be significant [e.g., (3, 6)] and, thus, cannot be disregarded in the present study. Premotor time and reaction time were nearly parallel functions, related to the preparatory interval within every condition. Since variations in reaction time which result from variations in the preparatory interval are attributed to anticipatory set, age differences in reaction time set may be attributed to differences between age groups in the premotor aspects of the response.

This study was an outgrowth and extension of one by Weiss (9). The extensions included use of both regular and irregular series, and included the expanded range of preparatory interval durations from 0.5 to 15.0 seconds. The reasons for these extensions may be found in the studies by Botwinick and Brinley (3, 4). It was found that a preparatory interval of 0.5 seconds played a different role in reaction time than longer preparatory intervals in the series. In addition, the regular and irregular series with this short prepara-

tory interval of 0.5 seconds appeared to require different abilities to respond quickly, abilities which were unrelated to an extent. Long 15.0-second preparatory intervals were considered important because reaction times of the aged tend to be extraordinarily slow with this preparatory interval duration. Therefore, an analysis of the relations between components of reaction time and age may best be made with those factors which maximize the limits of the problem.

The results with irregular series of the present study were similar to those of Weiss (9). The preparatory interval played a role in premotor time and not motor time. With regular series, however, the preparatory interval played a role in both premotor time and motor time. The preparatory interval played a role in motor time when both elderly and young Ss were considered together ($p < .05$), and when the data of only elderly Ss were analyzed ($p < .01$). When, however, the data of young Ss alone were examined, motor time differences due to the preparatory interval were not seen ($p > .05$). This explained the significant interaction between age and the preparatory interval with respect to motor time in regular series in Table 1 ($p < .05$). The interpretation of these results is not clear. If this is not a case of an error of accepting as statistically significant that which is not significant, then the elaboration and elucidation must await further study.

It does not seem likely, however, that these motor time results warrant serious attention. The actual magnitudes of the motor time differences were small, and the variations of the preparatory interval, and the interaction between age and the preparatory interval, were statistically significant only with .05 levels. With irregular series, neither the preparatory interval nor the interaction between age and the preparatory interval were statistically significant even with .05 levels.

Another extension of the study by Weiss (9) was the testing of both male and female Ss. There were no statistically significant sex differences, and age and sex did not interact significantly with regard to reaction time and its components ($p > .05$). However, there were interactions between sex and preparatory interval in reaction time and premotor time of regular series ($p < .05$). Thus, in the present study, the finding that elderly female Ss were quicker than elderly male Ss (3) was not supported. In fact, Figure 1 suggests that the elderly men were faster than elderly women in reaction time and premotor time; but variance analyses of the data of each age group separately indicated that sex differences were not statistically significant for reaction time, premotor time, or motor time ($p > .05$). The data of Figure 1 also suggest an age-sex interaction, but the variance analyses (Table 1) did not indicate

this ($p > .05$). Thus, if the status of the central nervous system is a correlate of speed of response, then the reaction time data of the present study did not suggest superior neural functioning of elderly women than elderly men.

E. SUMMARY

Reaction time was segmented into two component parts, premotor time and motor time. The reaction times and the components were analyzed in relation to four preparatory intervals within an irregular series and a regular series. These functions were then compared among subgroups comprising elderly males, elderly females, young adult males, and young adult females. The reaction times were segmented by the method of Weiss (9). Electromyograms were recorded from the extensor muscle of the responding forearm during measurement of reaction time. The time between stimulus presentation and occurrence of increased muscle firing was the premotor time; the motor time was the reaction time minus the premotor time.

Premotor times, motor times, and, therefore, reaction times were found to be slowed in advanced age. Interactions between age and sex were not significant ($p > .05$), indicating that whatever the antecedent mechanisms of the slowing process with advanced age may be, they may be the same for men and women.

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SELF-EVALUATION IN YOUNG CHILDREN*¹

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A. INTRODUCTION

The correct or accurate appraisal of reality is considered an important characteristic of mental health by such people as Jahoda (11). Jourard (12), for example, says that the more a person's beliefs depart from reality, the more deviant, ineffective, and unhealthy we might expect his behavior to be. He goes on to state that the criterion against which to compare the person's beliefs may be the opinion of qualified experts.

McCandless (13) has recently dealt with the literature on the "self-concept," which he sees as a set of beliefs or expectancies, plus evaluations of the behaviors with reference to which these expectancies are held. He goes on to point out that there is no way of knowing the "real" self. Our closest approximation, he says, is to compare the statements of a person about himself with judgments of people who know him well. Helper (10) also comments on the widespread agreement that self-evaluation attitudes are believed to arrive rather directly from evaluations made of the individual by others.

A systematic investigation of this problem, however, must contend with the paradoxical question of whose reality is more valid—the individual's internal or "subjective" view or another person's external or "objective" view. Sullivan (22) states that the self-structure is made up of "reflected appraisals," appraisals of the individual which were made by parents and significant others. The implication of these comments seems to be that as the parents and significant others defined and evaluated the person, so he would come to define and evaluate himself.

Crandall (6) in his discussion of the development of one of the parameters of achievement standards in children, the *source* of the achievement standards, deals directly with this issue. The standards that children employ to evaluate their competence, he says, may be based on their own subjective standards.

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Such children less often define the competence of their behavior on the basis of approval or criticism of others. They are said to hold autonomous achievement standards. Other children, in contrast, characteristically tend to look to other persons to define the competence of their performance. They mirror or reflect the standards of others and their standards are designated reflective. He says that developmentally it might be presumed that children who have developed autonomous achievement standards have more readily incorporated the achievement standards which significant others, such as parents, have held for them and have come to accept these standards as their own.

The present paper stems from a larger study dealing with the antecedents and consequences of preschool children's expectations of the demands of school. Within this study we have data pertaining to the child's evaluation of his own competence in meeting the demands of his world and the evaluations of the teachers of the children's capabilities in these matters. The purpose of this paper is to present the differences in behavior between those children who rely on their own standards of evaluation of competence and those who reflect or mirror the evaluative standards of the teacher. We will relate this measure of appraisal of competence, our independent variable, to several dependent variables: school and laboratory behavior, teacher ratings, maternal interview, and questionnaire data concerning achievement demands and sanctions.

B. METHOD

1. *Subjects*

Thirty-two middle-class kindergarten children in the Detroit area, 15 boys and 17 girls, and their mothers and teachers served as subjects.

2. *Measures*

a. Appraisal of competence. The measure of the child's appraisal of his competence was obtained from a structured-doll-play interview. Five social- and nonsocial-problem situations dealing with such content as competition, independence, and reactions to frustration were presented to the child by the junior author through a combination of verbal instructions and manipulation of the doll figures. The child was asked, using the dolls as a medium, to indicate what he would do to cope with the situation. His verbalizations and behavior were recorded verbatim by the experimenter.

The teachers these children had in nursery school were given these same situations in a questionnaire form and asked to describe how they believed this same child would handle the situations.

The five situations used with the child and teacher are as follows:

Teacher form

1. _____ and another child are playing with the bowling pins and ball. They appear evenly matched in skill and control. Soon, however, child X calls out, "I'm better than you. I knocked down more than you."
2. Child X and _____ are both pulling at a ladder, each screaming loudly, "I had it first."
3. _____ is building a garage. Child X has been annoying him by removing blocks and telling him how silly his garage looks.
4. The teacher brings a collection of boxes of different sizes, shapes, colors, etc., to school and puts them on the table.
5. _____ is dressing up in a costume and having difficulty with some piece of apparel.

Each item was followed by two questions:

What would _____ do in such a situation?

What would *you* do?

Along with other codes, each of the child and teacher story responses were coded for whether the child was expressing competence or incompetence in handling the situation. The definitions of competence and incompetence were as follows:

Competence—Child views self as effectively capable of handling the situation, solving the problem, functioning by his own efforts: example, remains with situational problem, states intended action or implies he will act.

Incompetence—Child views self as unable or incapable of handling the situation or the problem on his own: example, may leave the room, call for the teacher in a way clearly indicating his own feeling of incapacity, or insists that he cannot do it.

There was also a *no score* category.

Three judges, the junior author and two graduate students in child development, coded a sample of 21 subjects. The per cent of complete agreement between the three sets of coders ranged from 91 to 93 per cent, indicating good agreement for this category.

A competence index for each child and for his teacher was obtained by dividing the sum of competence codes by the competence-plus-incompetence codes. Each competence index was then normalized by using an arc-sign transformation (20).

An "accuracy" of appraisal-of-competence measure was obtained in the following manner. We first ran a discrepancy score by subtracting the child from the teacher-competence index. We disregarded sign—i.e., the direction

of the difference—being concerned only with the absolute size of the difference—and formed a distribution of the difference scores between the child- and teacher-competence indices. The distribution was divided at the median.² The 16 children whose appraisal of their own competence was highly discrepant from the teacher's evaluation of their competence—i.e., above the median—were termed low accuracy of appraisal of reality or, in Crandall's terminology, the *autonomous* appraisal-of-competence group (AAC); the 16 children whose competence indices were close to their teachers—i.e., below the median—were termed high accuracy of appraisal of reality or, again in Crandall's terms, the *reflective* appraisal-of-competence group (RAC). There were no sex differences in this appraisal-of-competence measure. Boys, that is, did not significantly differ from girls in whether their self-evaluation approximated the teacher's evaluation of them. Each group, then, has both boys and girls within it.

The behavior of these two groups on various dependent measures was then compared.

b. Classroom observations. Observations of these children in their kindergarten settings were made by the authors. There were 11 categories of task and social behaviors (see Table 1) which the observers were interested in assessing. Each of these behaviors was judged on a five-point rating scale. To establish reliability of the categories, six children were observed for a total of 19 joint observations; the per cent of agreement ranged from 74 to 100 per cent over the 11 categories with a median of 84 per cent. Each observer then spent one morning observing the children in our sample in his kindergarten classroom. The child was observed for a 15-minute period and then the child was rated on each category. An observation of the teacher for other purposes followed this child observation and following this, another 15-minute child observation was made. Thus, a rotation of child and teacher observations proceeded throughout the morning so that each child was observed from two to four 15-minute periods. At the end of the morning, the observer then made a final composite rating from his total morning's impressions of the child. The child's score in a given behavior rating scale was the pooled average of all the ratings made.

² We originally had planned to analyze all our data using four subgroups in which the child-teacher competence indices were equally high (HH), equally low (LL), child high but teacher low (HL), and child low but teacher high (LH). There were eight children in each subgroup using medial splits of the distributions. A Kruskal-Wallis H test (8) was applied to parts of the data. There were no differences between any of the four subgroups in the observation categories and so we abandoned this method of analysis.

c. Laboratory tasks. Laboratory measures of the child's level of aspiration and impulse control were obtained. The level of aspiration of each child was measured in a task devised by Sears and Levin (17) and adapted for the present study. Five differently colored rubber balls were hung from an adjustable rod on the ceiling. The easiest to reach was just within fingertip reach of the child, and each of the remaining balls was hung about three inches higher than the preceding one. The child was asked to choose the color of the ball he would try to hit on his jump. There were 10 trials. A weight of 5 was assigned to the highest or hardest ball to reach and a weight of 1 to the lowest or easiest ball to reach. From the child's choices a level-of-aspiration score was derived consisting of the weighted average over the 10 trials. The child's level of aspiration was obtained twice: while he was in nursery school and after he had been in kindergarten at least a month.

A measure of the child's ability to delay immediate gratification was obtained in a task adapted from Block and Martin (3). Each child was given the opportunity to accumulate as much candy as he wished, with the proviso that if he stopped to eat or taste a piece of candy, the game was ended. The candy was placed by the child, one piece at a time, into the cart of a toy known as a "Coke Loader." He cranked the handle which raised the cart until it tipped, emptying the candy into a large glass jar. The impulse-control score was simply the number of pieces accumulated in the jar at the time the child chose to eat the candy. The scores ranged from 8 to 50.

d. Teacher ratings. The child's kindergarten teacher rated him on 14 categories of behavior dealing with achievement, independence, and interpersonal behaviors. Most of these were adapted from Winterbottom (25) and the remainder were developed by the authors. Each of these behaviors was judged on a five-point scale; the items were randomized in the list given the teachers. Reliability of the ratings by the teachers using the present form was not feasible to obtain. These ratings, however, are the end result of three preliminary forms of the questionnaire; they represent those reliably rated by teachers with similar training.

Some of the categories listed in Table 3 were clustered into composite scores; the remainder are single-item categories. The composition of the categories used was as follows:

A. *Task or Instrumental Independence*

1. Overall independence.
2. Ability to do things in school on his own.
3. Ability to entertain himself or keep himself occupied.
4. Ability to look after himself in routines.

- B. *Emotional Independence*
 - 1. Response to adult authority: obedience—disobedience.
- C. *Achievement*
 - 1. Reaction when he does well in something.
 - 2. Overall competitiveness.
 - 3. Reaction to failure or difficulty with a task.
 - 4. Degree to which he wants to do well.
- D. *Emotional Control*
 - 1. Emotional mood swings.
 - 2. Overall impulsiveness.
- E. *Popularity*
 - 1. Degree of popularity with other children.
- F. *Assertiveness*
 - 1. Ability to stand up for his rights with other children.
- G. *Originality*
 - 1. Degree of conventionality-originality.

e. *Maternal behavior.* Data on maternal behavior were obtained from three different sources. The first source was a coding of the mothers' reactions to a set of five story-completion situations depicting children's behavior. Each was asked to indicate how she would respond to the situation described and this response was rated on a five-point scale of power-assertive behavior. The power-assertive score used in the present analysis was the mean rating for each mother on these five stories. Power-assertion definitions, reliabilities for the coding, and the stories used can be found in a previous article by the authors (7).

The second source of maternal-behavior data involved a coding of the mother's response to an interview question (18) concerning the handling of dependency behavior on the part of the child: i.e., "How do you generally react if X asks you to help him with something you think he can probably do by himself?" The coding of the mother's behavior was on a five-point scale of unresponsiveness.

The third source of parent data was a questionnaire in which the degree of power-assertion expressed by the mother was measured (19). Following a description of each of 15 adult-child conflict situations, eight multiple-choice responses were presented varying in the degree of control expressed—that is, how much choice is allowed the child. The parent checked the behavior that best fitted her own preferred and usual way of handling the conflict. Five of these situations were achievement or autonomy related so that a parental power-assertion score around achievement was obtained by averaging the mother's weighted responses over these five stories.

3. *Data Analysis*

Nonparametric statistics were used since the data were considered to be ordinal in nature. The White test (8) was used for testing the significance of the differences between the two appraisal-of-competence groups. The rank-difference correlation, ρ , was used for all measures of association.

The mean scores presented in the tables were not used in the tests of statistical significance but are reported solely for the purpose of communicating to the reader the extent and direction of the differences between the two groups of children.

C. RESULTS

1. *Kindergarten Observations*

The observation findings seen in Table 1 indicate that the AAC group were significantly more competent in handling the kindergarten situation; they expressed more friendliness to the teacher and other children; they expressed more competitive behavior; they shared more; and they initiated activities in the kindergarten more than the RAC group. It should be noted, moreover, that all the comparisons, except for the ego-control variable, were in favor of the AAC group. These children, then, whose evaluations of their own competence were very divergent from those of the teachers, are the children whose social and nonsocial interactions are most expansive and most easily expressed. The RAC group, in contrast, those children whose evaluations of their own competence most closely mirror or parallel the teachers' evaluations, are the ones who were rated by the observers as less competent, less friendly to teachers and children, less competitive, less sharing, and who need help more often in initiating activities.

2. *Laboratory Tasks*

These differences in kindergarten behavior, especially those concerned with independence behavior, lend support to the notion that the RAC group does need external confirmation of their own capacities, and do not have a stable, internal frame of reference about their performance.

The level-of-aspiration results yield additional data which confirm this supposition. Table 2 indicates that there is no relation between the child's mean level-of-aspiration score on Test 1 (nursery school) plus Test 2 (kindergarten) and whether appraisal of competence is reflective or autonomous. But the greater the reflective-appraisal-of-competence score, the greater is the average shift either up or down in level of aspiration from Test 1 and Test 2. An interpretation of this finding is that the RAC children are uncertain as to

the adequacy of their performance without the availability of an outside criterion. Since no external frames of reference are present in the level-of-aspiration situation, they are more unstable in their level-of-aspiration behavior.

That this fluctuation is not necessarily an indication of greater generalized flexibility, moreover, can be found in the correlation of appraisal of competence

TABLE 1
KINDERGARTEN OBSERVATION DIFFERENCES BETWEEN AUTONOMOUS AND
REFLECTIVE APPRAISAL OF COMPETENCE GROUPS

Observation category	Mean rating	
	RAC	AAC
Competence in handling kindergarten	3.81	4.48*
Involvement	3.67	4.00
Friendliness to teacher	3.62	4.10*
Friendliness to other children	3.62	4.18*
Competition	2.50	3.43*
Sharing	3.16	3.63*
Ego control	3.46	3.26
Compliance	1.77	1.95
Interest	3.61	3.94
Persistence	4.18	4.39
Initiation of activities	3.36	4.12*

* $p < .05$.

TABLE 2
RELATION BETWEEN LABORATORY TASKS AND AUTONOMOUS-REFLECTIVE
APPRAISAL OF COMPETENCE ($N = 32$)

Laboratory task	Rho
Level of aspiration:	
Mean level of aspiration	.03
Level of aspiration shift	-.66**
Impulse control	-.39*

* $p < .05$.

** $p < .01$.

and impulse control. The more the child's self-evaluation reflects the teacher's evaluation, the greater the impulse-control score (Table 2).

3. Teacher Ratings

Analysis of the differences in behavior between the two groups shows the AAC group to be significantly more achievement oriented (Category C in Table 3). The AAC group is also rated as manifesting significantly more originality (Category G) in their activities in the classroom.

Correlational analysis of the behavior ratings of the teachers are consistent with these and our other findings. The more the child's appraisal of competence is autonomous rather than reflective, the less cautious and more impulsive but also more variable in mood (Category D) he appears to the

teacher ($\rho = .39, p < .05$). Finally, we also find that the more autonomous the child's appraisal of competence, the more he is rated by the teacher as achievement oriented (Category C, $\rho = .49, p < .01$) and original (Category G, $\rho = .54, p < .01$).

4. Maternal Behaviors

What then are the conditions in these children's home environments that relate to these differing modes of appraisal of competence? The maternal data point to high control and low nurturance's being related to reflective appraisal of competence. The more responsive the mother is when the child asks for help in something the mother thinks he can do by himself, the more the child's

TABLE 3
TEACHER RATING DIFFERENCES BETWEEN AUTONOMOUS AND
REFLECTIVE APPRAISAL OF COMPETENCE GROUPS

Teacher rating category	Mean rating	
	RAC	AAC
A. Task independence	4.01	4.06
B. Emotional independence	2.30	2.44
C. Achievement	3.33	3.96*
D. Emotional control	2.98	2.78
E. Popularity	3.60	3.44
F. Self-assertion	3.56	4.01
G. Originality	3.11	3.80*

* $p < .05$.

self-evaluation mirrors the teacher's evaluation of him ($\rho = .32, p < .10$). The more power-assertive or controlling the mother is around achievement and autonomy, the more the child again reflects the evaluation of the teacher ($\rho = .34, p < .10$). Both these correlations do not reach acceptable levels of statistical significance, but they are in the expected direction. The third source of maternal data is statistically significant and indicates that the more the mother's power-assertion score in the story completions, the more the child's self-evaluation mirrors or reflects the evaluation of the teacher ($\rho = .40, p < .05$). Autonomous achievement standards would seem to develop in a home atmosphere where the child's attempts to master his environment are supported by his mother. It would seem that the child needs a learning atmosphere in which he can reduce the gap between what he knows should be done and what he actually can do.

D. DISCUSSION

Our results indicate that high maternal control and low maternal nurturance tend to be present in the homes of children we have postulated to need external

sources for evaluating their own task-oriented, independence behavior. These children, in turn, show less capacity to cope with the demands of their school situation.

Our conceptual framework has grown out of and been consistent with that of McClelland (14) and Atkinson (1) who say that achievement motivation develops out of growing expectations of one's own capacities. The aspect of the theory that is most germane to the present results states that unpleasantness and avoidance motivation results from too large a discrepancy between expectations and event.

Winterbottom (25), in work stemming from these theoretical notions, reported a positive relationship between early independence training and later achievement motivation as McClelland used the term. Chance (4) and Gordon (9), on the other hand, reported that children exposed to early independence-training demands by mothers were not as achievement oriented or as productive as might be expected. There were methodological differences between the studies with Chance concerned with actual achievement and Winterbottom with need for achievement as measured by the TAT. But the findings do suggest that there is an optimum time and climate in which independence behavior is fostered. The lack of maternal responsiveness we found in the mothers of the RAC group interacting with the mother's expectations may serve to increase avoidance motivation in the child and to reduce the degree of coping behavior of the sort expressed in our competence index.

Baumrind has recently reported some data pertinent to this discussion (2). She finds that preschool children highest in observed self-sufficiency and approach tendencies to the world had parents whose behavior was rated highest in control *and* nurturance. She concludes that highly competent child behavior can result from different degrees of control relative to nurturance provided that both are high. She goes on to say that parental control and nurturance are synergic, supporting a point of view about parental behavior we feel needs to be stressed (23). Baumrind explicitly did not study what she termed "covert dynamic forces" with which this paper is dealing and which we believe to be highly important in the study of achievement and independence behavior.

It would seem necessary, then, to carry the problem of the development of self-evaluation in children further by seeing if the children who have reflective appraisals of competence have typically been placed in situations where the expectations of others about their performance were clearly beyond their capacity to confirm. High standards of performance may have very early been

specified for them at a time when they were incapable of meeting the standards.

One of the major limitations of these data is that we do not have measures of father's response to dependency demands from the child. The role of the father has been demonstrated to be critical in the development of independence and task-oriented behaviors (15, 21) and we would have liked to include them in our study. Time and personnel limitations made this not possible. The only measure of father behavior we do have is fathers' response to the five achievement and autonomy questionnaire items scored for degree of power-assertion expressed. These data were collected by Halawi for other purposes (19). It will be recalled that we found a nonsignificant tendency for mother's power-assertion around achievement and autonomy to be related to the child's self-evaluation being more reflective of the teacher's evaluation of him. In contrast, we find a *reverse* but also nonsignificant tendency for the father's power-assertion or control on this measure to be related to the child's self-evaluation being more autonomous of the teacher's evaluation of him ($\rho = -.20$, $p > .10$). The difference between the two correlations is, however, not significant (Fisher's $z = .37$, $p = .70$). A number of uncontrolled variables could be operating here like the sex of the child, ordinal position, and sex of siblings which future work should take into account when studying the effects of father's power-assertion on child behavior.

These results confirm some general conclusions reached by Coopersmith (5) in his study of fifth- and sixth-grade children. He secured a high self-esteem but low teacher-esteem group (HL) and a low self-esteem but high teacher-esteem group (LH). These two groups correspond to our AAC group and of them he says that the HL and LH groups "... appear to be similar in their refusal to accept the *status quo* and are marked by high achievement motivation, a high level of anxiety . . . and an ideal beyond immediate reach (p. 92)." From these and other findings he questions the usual definitions of adjustment which emphasize the accuracy of perception according to which the HL and LH groups would be considered maladjusted. We concur with Coopersmith that definitions of adjustment defined solely in terms of passivity and acceptance are often inappropriate and inadequate.

The group of children whom we have designated as having an evaluation-of-self autonomous from that of their teachers seems to have made substantial gains in the achievement of competence in the sense that the concept has been used by White (24). Maximum motivation, he and others conclude (16, 24), does not necessarily lead to the most adequate problem solving. We need further work in the parental behaviors fostering this optimum problem-solving orientation and feelings of self-worth.

E. SUMMARY

Accuracy of self-evaluation of competence was measured in 32 kindergarten children. Two groups were formed on the basis of whether self-evaluation was different from or similar to teacher's evaluation. Level-of-aspiration and impulse-control measures were obtained from the children; kindergarten behavior observations, teacher ratings, and maternal behavior data were also obtained. The children with more autonomous self-evaluations manifested more independence and achievement as well as more affiliative behaviors in kindergarten. Overcontrol of impulse and less stable levels of aspiration characterized the groups with less autonomous self-evaluations. Maternal control was more characteristic of the mothers of the less autonomous group. Implications of these data for the development of self-evaluation is discussed.

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THE DEVELOPMENT OF DISCRIMINATED AUTONOMIC
AND INSTRUMENTAL RESPONSES DURING
AVOIDANCE CONDITIONING IN THE
RHESUS MONKEY*¹

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A. INTRODUCTION

Selection of a response measure is a problem in all investigations of learning. Although the most commonly used measures employ changes in performance on some standardized task as a means of assessing the effect of instructions, practice, etc., there exist a variety of paradigms that may be more useful in determining the effect of such variables. Since Pavlov's earliest work, the measurement of physiological changes during training has proved to be a very sensitive technique in studying the learning process. Moreover, several prominent theories of learning depend heavily upon assumed intervening emotional states to explain learning phenomena, and these emotional states presumably have autonomic concomitants.

The present investigation was designed to measure the changes occurring during training in one type of autonomic activity (namely, cardiac rate) and, if possible, to elucidate the relationship between these changes and the acquisition of a discriminated instrumental avoidance response.

Gantt and his colleagues have carried out an extensive program of cardiac conditioning and have found that motor CRs develop later than do cardiac and respiratory CRs (10), but they have utilized only a classical-conditioning paradigm.

Among the relatively few studies in which heart rate has been recorded during instrumental conditioning are those by Black (1)—as reported by Solomon and Brush (12), and by Stern and Word (14). Experimenters in both studies obtained significant changes in heart rate very early in the process of conditioning when only a small number of avoidance responses were being

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made, but in neither study did the authors discuss in detail the relative rate of development of the two types of responses. Of more relevance to the present study is an experiment by Graham, Cohen, and Shmavonian (3) in which human subjects were required to learn a discriminated instrumental avoidance response, and GSR and heart-rate changes were recorded. Graham, Cohen, and Shmavonian found that GSR differences between positive and negative stimuli began to emerge in trials prior to the first avoidance response, while cardiac changes did not appear except on trials on which an avoidance was made.

B. METHOD

1. Subjects

The subjects in the present study were 22 male and one female feral rhesus monkeys (*Macaca mulatta*). Weights at the beginning of the experiment ranged from 11 to 18 pounds. Because no more than three animals could be accommodated at one time, seven replications with three-animal groups and one replication with a two-animal group were run.

2. Apparatus

A modified Dodge mirror tachistoscope, modeled after one developed at New York University (5) was used. It consisted of an F-shaped unit with two stimulus-presentation windows and one fixation window. Lighting and interior design were similar to that of the New York University tachistoscope except that an additional stimulus-presentation window was provided. The arms of the unit were made of plywood, with the interior painted flat black. The distance from the front of the unit to each stimulus panel was 35 inches, and the interior of the arms was nine inches in height and in width. The conditioning stimuli were a white disc and a white "X" of equal area and brightness. The fixation stimulus was an evenly illuminated black card, with the intensity of the lighting so adjusted that no perceptible change in overall brightness occurred when either of the two conditioning stimuli were presented.

The tachistoscope unit was mounted on a light-proof, sound-resistant enclosure 31 inches wide, 51 inches high, and 33 inches deep into which a monkey in a primate chair could be inserted; and a vertical sliding door closed. The interior of the box was painted flat black. A small fan was mounted in the box to provide ventilation and to mask extraneous noise.

A modified Grass polygraph was used to record heart rate, trial and shock

presentation, and bar presses. A cumulative counter was used to obtain total bar presses.

Shock was delivered by a standard-shock power supply with output currents adjustable from one to 30 ma.

All recording and control apparatus was located in a room adjacent to the experimental chamber.

3. Procedure

a. Adaptation. Each monkey was placed in a primate chair one week before trials were begun in order to allow it to become accustomed to the restrictive environment. The chairs were carefully inspected and adjusted daily to provide maximum freedom of movement and comfort. The height of the chairs was adjusted for each animal, so that eye level was maintained at the center of the tachistoscope aperture.

After the preliminary period, adaptation trials were begun. Each day before the trials the monkey was wheeled into the experimental room, and its legs were restrained with soft chamois straps in order to decrease artifact from muscle movement. Electrodes for recording heart rate were attached to each side of the chest and to the left thigh; shock electrodes were attached to each ankle. A response lever was mounted on the chair, the monkey was put into the light-proof box, the door was closed, and the ventilating fan was turned on; then the experimenter left the room. After a one-minute adaptation period, the heart rate of the monkey was recorded for one minute to provide a pre-session baseline; then conditioning trials were begun. At the end of the trials on each day, heart rate was recorded for one minute to provide a post-session baseline.

Twenty trials a day were given, 10 with the "X" and 10 with the disc, according to the Gellerman series (2). The average intertrial interval was one minute. CS length was six seconds. Heart rate was recorded for six seconds prior to the presentation of the stimulus and for 12 seconds after the onset of the stimulus. To determine whether the initial heart-rate response was the same to both stimuli, six days of preliminary trials were given. These were identical in every way to the subsequent conditioning trials except that shock was never presented. Bar-press responses were recorded continuously throughout the sessions.

b. Conditioning. If the subject showed a differential heart-rate response to the two stimuli during adaptation, the stimulus that elicited the lesser change was selected as the positive (shock) stimulus; otherwise the stimuli were chosen in such manner that the number of Ss having the "X" as the

positive stimulus was equal to the number of Ss having the disc as the positive stimulus.

For this experiment a conditioned response (CR) is defined as a bar press occurring during the presentation of the positive stimulus; a false conditioned response (CRF), as a bar press occurring during the presentation of the negative stimulus; and a spontaneous response (SR), as a bar press occurring at any other time.

During conditioning, the stimulus was presented for a constant six-second period; i.e., the stimulus was not response terminated and did not overlap the shock. If an avoidance response was not made within the CS-US interval, shock ensued at six seconds and continued until the animal made a response or, during the early stages of conditioning, until the experimenter terminated the trial. To facilitate acquisition of the response, the intensity and duration of the shock were adjusted by the experimenter and an eight-inch bar was used for the first few trials. As the animal learned the response, the length of the bar was gradually shortened to two inches, and the level of shock was reduced to the minimum level consistent with effective escape-avoidance behavior. If a bar press did occur during the CS-US interval, the shock was avoided; but the stimulus continued for the full six seconds. The acquisition criteria were 90 per cent or more avoidance responses to the positive stimulus and less than 25 per cent responses to the negative stimulus (results being averaged over three successive days). If, within sixty days (600 trials to each stimulus), a monkey did not reach the foregoing criteria it was considered a nonlearner.

C. RESULTS

1. *Acquisition of the Avoidance Response*

Fourteen monkeys (Group L) reached the criteria for both the positive and the negative stimuli within 60 days. Nine animals (Group NL) failed to reach either one or both criteria in the same period. In the latter group four monkeys reached neither criterion, and five monkeys reached the criterion to the positive stimulus only. Table 1 presents data on the acquisition of the avoidance response.

The four animals which reached neither criterion learned to make a short-latency escape response, but made few SRs and almost no avoidance responses. The other five animals in Group NL were slower to reach the positive criterion than the monkeys in Group L (35.6 days *vs.* 25.9 days), but did learn to respond to the stimuli rather than to avoid the shock by pressing the bar at a high rate. For the three criterion days, the mean number of SRs made

by each monkey per day was slightly greater for these five animals than for the animals in Group L (103.3 SRs and 80.3 SRs respectively), but even the larger figure is less than a third of the minimum number of responses required if the monkey were to reach criterion by pressing the bar at a regular rate.

2. Baseline Heart Rate

Because different numbers of trials were required for each animal to reach the criteria it is possible to combine data only for certain periods for which it seems reasonable to assume that the subjects were roughly at the same stage of learning. Table 2 gives the mean baseline heart rate during the six adapta-

TABLE 1
MEAN NUMBER OF DAYS REQUIRED TO REACH CRITERIA

Group	Days to reach positive criterion	Range	Days to reach both criteria	Range
L	25.9	15-47	31.7	17-60
NL	46.4	23-60 +	60.0 +	60-60 +

TABLE 2
MEAN BASELINE HEART RATE

Baseline period	Adaptation		First six conditioning days		Final six conditioning days	
	Group L	Group NL	Group L	Group NL	Group L	Group NL
Presession	187.1	173.9	197.6	187.9	193.9	187.2
Postsession	167.2	156.9	193.1	183.1	163.2	174.8
Mean	177.1	165.4	195.3	185.5	178.5	180.7

tion days, the first six conditioning days, and the final six conditioning days. Although, during the first two comparison periods, the subjects in Group NL showed a tendency toward a lower heart rate than those in Group L, none of the between-group differences is significant.

3. Conditioned Changes in Heart Rate

Heart-rate changes were calculated by subtracting the per-minute heart rate for the six seconds prior to stimulus presentation from the heart rate during the six seconds of stimulus presentation (D_1) and from the heart rate of a six-second poststimulus period (D_2). A mean heart-rate change per day was obtained for each period (D_1 and D_2). Because the degree of the heart-rate change to the positive stimulus in the D_2 period was confounded by shock presentation on escape trials, heart rate for this period was recorded only when an avoidance had been made, and these data are reported only for days

on which a subject made at least 40 per cent avoidances.

Table 3 presents heart-rate conditioning data for the three comparison periods. As would be expected, no significant differences exist either within or between groups for the adaptation period. In the first six conditioning days, however, the animals in Group L showed a greater change in heart rate to the positive stimulus than to the negative stimulus, while the subjects in Group NL did not. During the same period, Group L showed a significantly greater heart-rate change to both the positive stimulus ($p < .05$) and to the negative stimulus ($p < .02$) than did Group NL.

In the final six conditioning days, both groups showed significantly greater change to the positive stimulus than to the negative. Thus, the animals in Group NL discriminated autonomically between stimuli even though the discrimination was not reflected in their performance of the bar-press response. Group L, however, still showed greater change than Group NL to the positive stimulus ($p < .01$), although the comparable comparison for the negative stimulus was no longer significant.

The problems of evaluation of the cardiac responses have been extensively discussed by Lacey (6). He has shown that a simple comparison of amount of change in heart rate upon stimulation is frequently not an entirely adequate measure because of what he refers to as "the law of initial values"; i.e., the magnitude of the response is related inversely to the prestimulation or baseline level. To get a more sensitive measure, another type of analysis of the data was made.

It will be recalled that heart rate was recorded for one minute immediately preceding and one minute immediately after the daily trials. To obtain a measure of spontaneous change in heart rate for intervals comparable to those used in conditioning, the total of the two minutes was divided into 10 12-second intervals. Within each such interval the per-minute heart rate of the first six seconds was subtracted from that of the last six seconds, and a mean change was obtained for each day. Based upon the standard deviation of the distribution for the entire series of sessions for a given animal, the change in heart rate required for significance at the .05 level was determined. Using that figure it was possible to determine for each animal whether or not change in heart rate on a given day (to either stimulus) was significantly greater than would be expected by chance fluctuations alone. This analysis allows for individual differences in baseline and lability of heart rate, and the authors believe that it gives a more meaningful comparison than could be obtained from group data alone.

Table 4 presents the data derived from the foregoing analysis. For each

TABLE 3
MEAN CHANGE IN NUMBER OF BEATS PER MINUTE IN HEART RATE IN INTERVAL D_1

Group	Six adaptation days			First six conditioning days			Final six conditioning days		
	Positive stimulus	Negative stimulus	Within Group P	Positive stimulus	Negative stimulus	Within Group P	Positive stimulus	Negative stimulus	Within Group P
Group L	2.4	2.7	NS	5.4	4.0	<.01	18.3	5.5	<.001
Group NL	2.4	2.5	NS	3.1	2.4	NS	10.2	7.1	<.05
Between Group P	NS	NS		<.05	<.02		<.01	NS	

animal, the number of sessions in which a significant heart-rate change occurred was converted to a percentage of total sessions because different numbers of sessions were required for each monkey. Because heart-rate changes to the positive stimulus were not recorded in all D_2 periods, significant changes to the negative stimulus in the D_2 period were counted only for days on which changes to the positive stimulus were also recorded.

The data show that both groups achieved a high level of discrimination between stimuli, although the proportion of significant heart-rate changes to the

TABLE 4
PERCENTAGE OF SIGNIFICANT HEART-RATE CHANGES

	D_1			D_2		
	Positive stimulus	Negative stimulus	Within Group P	Positive stimulus	Negative stimulus	Within Group P
Group L	79.96	45.05	< .01*	94.78	55.69	< .01*
Group NL	48.89	35.56	< .01*	88.00	69.33	< .01*
Between Group P	< .01**	NS**		< .02**	NS**	

* Wilcoxon test for paired replicates.

** Mann-Whitney U test.

positive stimulus was higher for Group L than for Group NL. The two groups were not different in the proportion of significant heart-rate changes to the negative stimulus.

4. Comparison of Heart Rate and Bar Press Conditioning

To compare the relative rate of conditioning of the heart rate and bar-press responses, the data were divided into Vincentized tenths—excluding in the usual way the three-day criterion period [Hilgard and Campbell (4)]—and, within each tenth, the number of conditioned bar-press responses (CRs and CRFs) and the number of significant heart-rate changes were converted into percentages of the total possible conditioned bar presses or significant heart-rate changes.

For Group L (Figure 1) the percentage of significant heart-rate changes to the positive stimulus was larger than the percentage of CRs, even in the first tenth. The difference between heart rate and CR curves increased rapidly until the sixth interval at which point the heart-rate curve approached an asymptote and, thereafter, the difference decreased slowly. The sign test for the difference between these curves is significant at the .002 level.

Comparison of the aforementioned curves with those of responses by Group L to the negative stimulus shows that heart-rate discrimination began after

the first tenth (approximately 30 trials) and bar-press discrimination after the third tenth.

For Group L, a sign test of the difference between the heart rate and CRF curves of responses to the negative stimulus is also significant at the .002 level, with the percentage of significant heart-rate changes being consistently greater than the percentage of CRFs.

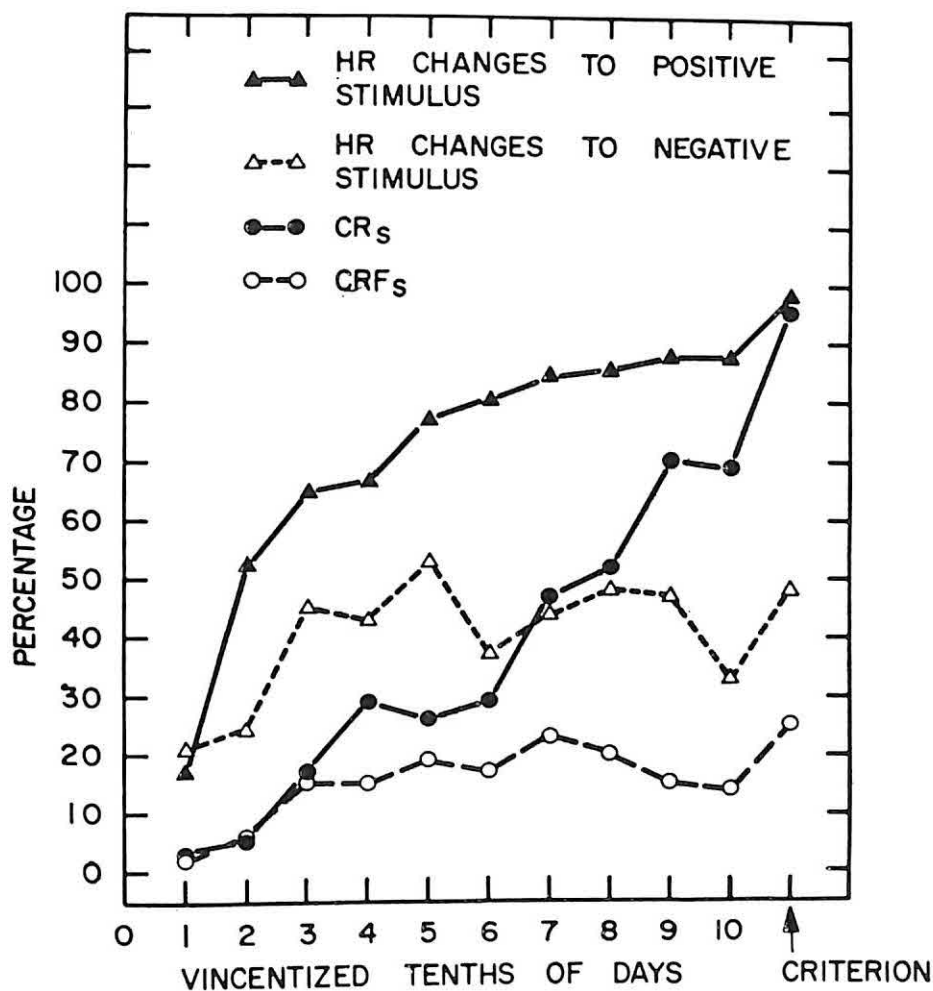


FIGURE 1
VINCITIZED CURVES OF THE PERCENTAGES OF BAR-PRESS RESPONSES AND SIGNIFICANT
HEART-RATE CHANGES (D_1) PRIOR TO REACHING THE POSITIVE
CRITERION (GROUP L)

For the positive stimulus, 35.5 per cent of all significant heart-rate changes occurred in the first half of conditioning as opposed to 16.4 per cent of all CRs ($p < .01$), indicating that the heart rate did, indeed, condition more quickly than the bar press in Group L.

In a similar comparison of responses to the negative stimulus, 50.9 per cent of all significant heart-rate changes and 38.1 per cent of all CRFs were made in the first half. This difference is not significant.

Figure 2 presents the same curves for the five Group NL animals which

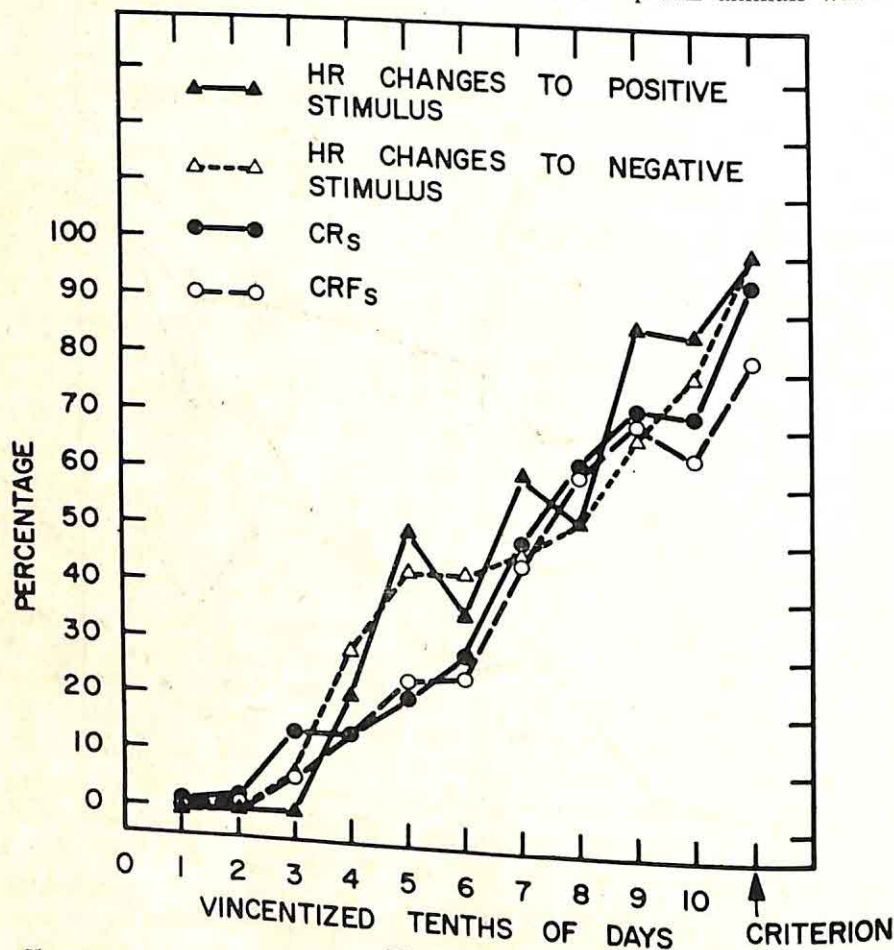


FIGURE 2
VINCENTIZED CURVES OF THE PERCENTAGES OF BAR-PRESS RESPONSES AND SIGNIFICANT HEART-RATE CHANGES (D_1) PRIOR TO REACHING THE POSITIVE CRITERION (GROUP NL—FIVE Ss)

reached the positive criterion. Sign tests reveal no significant differences in the development of the two types of responses (heart rate and bar press) for either the positive or the negative stimulus and no differences for either stimulus in the percentage of the two types of responses made in the first half of the trials. Thus, for these animals, heart-rate changes did not appear prior to the appearance of the bar-press response, in contrast to the findings for Group L.

D. DISCUSSION

The results of this experiment reveal that there are marked differences in autonomic responsiveness of monkeys in a discriminated avoidance situation and that these differences are related in a meaningful way to the instrumental performance on the task. Specifically, the data show that a discriminated instrumental avoidance response is established in only those animals which manifest a discriminated cardiac response prior to the acquisition of the motor response.

These results are relevant to the two-process theories of learning, such as those set forth by Mowrer (8), Miller (7), and Solomon and Wynne (13), in which associative conditioning of emotional responses is assumed to precede and provide the motivation for the learning of the instrumental avoidance response. In Group L, the relatively faster rate of development of the heart-rate response (in contrast with that of the bar-press response) to the stimuli (Figure 1) is consistent with such theories. However, interpretation of the data for the five Group NL animals which reached the positive criterion is not so straightforward. These animals showed no evidence of heart-rate response before the fourth interval (Figure 2) *vs.* the first interval for Group L; the development of the heart-rate response to the positive stimulus paralleled that of the bar-press response, in marked contrast to the development of these responses in Group L. For the three-day criterion period, however, both groups were virtually equal in the percentage of CRs and significant heart-rate changes to the positive stimulus. The most important difference between the groups, therefore, is not in their final performance levels but in the delayed acquisition of the heart-rate response by Group NL and in the lack by this group of a bar press discrimination between stimuli.

These results can be interpreted as partially confirming the two-process theories in that in Group L the conditioning of the heart rate did precede the learning of the avoidance response. That it did not do so in the Group NL animals which reached the positive criterion implies that the two-process theories are not entirely adequate and that in the learning process, the major

role played by the prior conditioning of autonomic responses is related to the formation of discriminations rather than to the learning of the avoidance response.

Theoretical interpretation of the conditioned heart-rate response always offers some difficulty because of the effect on heart rate of variables such as respiration and muscle movement. Investigators have disagreed as to the importance of these variables. For example, Smith (11) has suggested that all conditioned heart-rate responses are artifacts of concomitant activity, while Peters and Gantt (9) have minimized the effect of activity. In the present experiment, as can be seen from Figure 1, a sizeable heart-rate change occurred in the virtual absence of the bar-press response, and the rates of acquisition of the two types of response were quite different in Group L. It is possible, of course, that other types of activity not directed to the response bar could have been associated with the early large heart-rate increase. However, the size of the heart-rate change tended to increase up to an asymptote, while the number of responses per trial decreased throughout the learning period. In the final six conditioning days, when efficiency of response should have been at a maximum, the mean heart-rate change in Group L was over 18 beats a minute (Table 3). In Group NL, the mean change in number of beats per minute was significantly less, although these animals made an equally large number of avoidance responses. For the foregoing reasons it seems unlikely that concomitant activity can be a complete explanation of the large heart-rate changes obtained.

The sensitivity of the heart-rate response as a measure of learning was demonstrated in the present experiment. Although the five animals which reached only the positive criterion pressed almost equally often to both stimuli (Figure 2), these "nonlearning" Ss did show a high degree of discrimination in their heart-rate response at the end of conditioning, both in percentage of significant heart-rate changes (Table 4) and in the mean change in number of beats per minute in the final six conditioning days (Table 3). These findings imply that heart rate can be used profitably when, for an avoidance task, a sensitive measure of learning is required.

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THE EFFECTS OF FOOD DEPRIVATION ON UNREINFORCED AND LIGHT-REINFORCED BAR PRESSING*¹

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A. INTRODUCTION

The purpose of this study was to assess the effects of food deprivation on unconditioned and light-reinforced bar pressing. Previous research (2, 4, 5, 6) employing short test sessions of 15- to 30-minute duration indicates that food-deprived rats barpress more frequently for light reinforcement than satiated rats. It is unclear, however, whether the elevation in conditioned responding results directly from an enhancement of the reinforcing properties of light or indirectly from an increase in the rate of unconditioned bar pressing. Those investigations which have secured estimates of the effects of food deprivation on unconditioned bar pressing have produced apparently contradictory findings. Davis (2) and Forgays and Levin (4) found that deprived rats responded more frequently than satiated rats; Segal (6) found that deprived rats responded less frequently than satiated rats.

In the present study, prolonged free-operant testing was given prior to the beginning of light-reinforcement sessions. Prolonged testing permitted a detailed analysis of the effects of food deprivation on unconditioned bar pressing and furnished a stable baseline against which to evaluate light-reinforced responding. Two light-reinforcement conditions were employed: (a) the standard condition in which successive bar presses produced light from a single, invariant source within the test chamber and (b) a stimulus-change condition in which successive bar presses produced light from either of two alternating sources. The stimulus-change condition has previously been shown to produce a higher rate of responding than the standard light-reinforcement condition (3).

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B. METHOD

1. *Subjects*

Thirty-two hooded rats (Long-Evans Strain, Harlan Industries), 110 to 130 days old, and of both sexes served as Ss. The animals were maintained on a normal light-dark cycle in the laboratory for seven to 18 days prior to the beginning of the experiment.

2. *Apparatus*

Throughout the experiment, the animals were kept in two types of enclosures—a standard operant test chamber or a light-tight isolation box. The dimensions and construction of both enclosures have been fully described in an earlier report (3). Briefly, one wall of each test chamber contained four white pilot lamps (17.2 mV) arranged in a rectangular pattern and symmetrically located about a response bar. When not in the test chambers, the Ss were kept in living cages inside the isolation boxes. The test and isolation enclosures were sound-attenuating and were ventilated by blowers which also furnished a masking noise. Four enclosures of both types were used in the experiment. Each chamber and box was used equally often in the various treatment conditions. The programming of experimental events and recording of responses were accomplished by equipment located in an adjacent room.

3. *Procedure*

Seven days prior to the beginning of the experiment, one half of the Ss were placed on a 24-hour feeding schedule and a reduced food ration until they had reached 80 per cent of normal body weight. The remaining Ss had continual access to food.

The daily testing procedure consisted of seven hours in the isolation box followed by 17 hours in the test chamber (5 p.m. to 10 a.m.). All animals had free access to water in both enclosures and were weighed when removed from the test chamber. The satiated animals had a continuous supply of food available in both enclosures. The deprived animals never received food in the test chamber but were fed a daily ration sufficient to maintain 80 per cent of normal body weight when they were returned to the isolation box.

The experimental plan consisted of two operant sessions in which bar pressing was not reinforced, six conditioning sessions in which bar pressing was reinforced by light onset, and three extinction sessions in which bar pressing was again unreinforced. The duration and number of sessions required to achieve stable behavior under each of the above conditions were determined

from pilot experiments reported elsewhere (3). At the completion of the operant sessions, half of the deprived animals were randomly assigned to the single position light-reinforcement condition (hereafter called the SP group) and half to the alternating position light-reinforcement condition (hereafter called the AP group). Only the two light positions located above the bar to the left and to the right were used in the conditioning sessions. In the SP group, responding caused light onset from the upper-right position for half the animals and from the upper-left position for the remaining half. In the AP group, successive responses caused light onset from the upper-right and upper-left positions in alternating fashion for all animals.

The number of responses during 15-minute periods within the operant, conditioning, and extinction sessions was recorded.

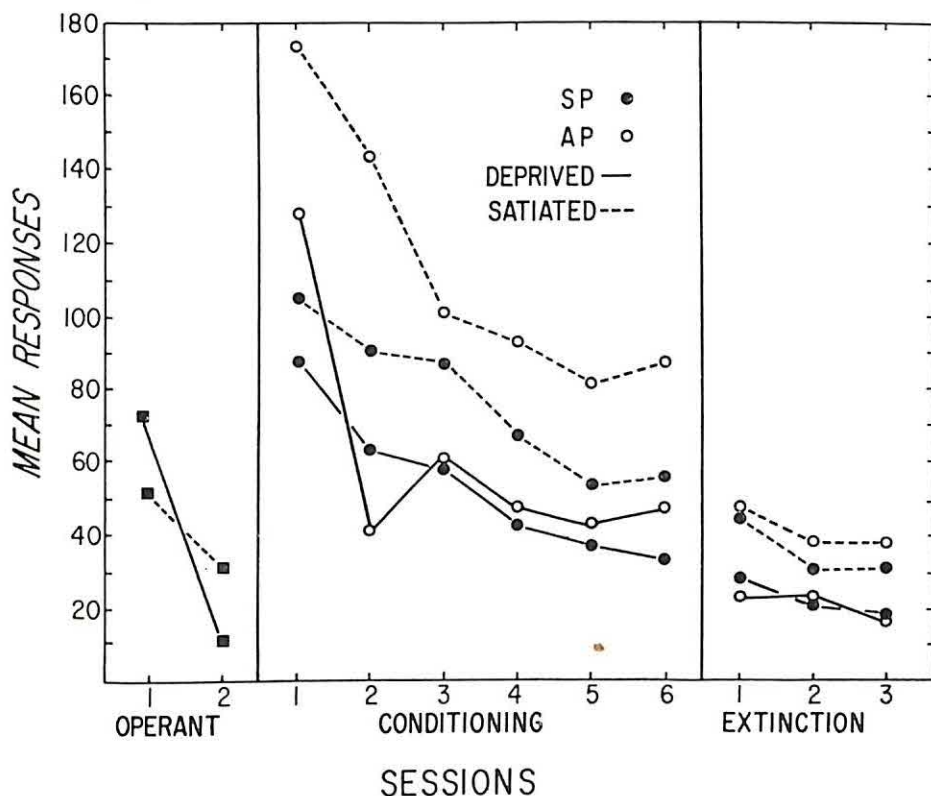


FIGURE 1
THE MEAN NUMBER OF RESPONSES DURING THE OPERANT, CONDITIONING, AND
EXTINCTION SESSIONS FOR EACH DEPRIVATION AND
LIGHT-REINFORCEMENT CONDITION

C. RESULTS

1. *Operant Sessions*

The left panel of Figure 1 indicates the total number of bar presses emitted by the deprived and satiated Ss during the two operant sessions. In both deprivation conditions, the frequency of unconditioned responding decreased from the first to the second session ($F = 42.10$; 1, 24 *df*; $p < .001$). However, the deprived Ss responded more frequently than the satiated Ss during the first session, but less frequently during the second session ($F = 10.25$; 1, 24 *df*; $p < .01$). When responding during the first session was examined in successive 15-minute blocks, the deprived Ss were found to be responding more frequently only during the initial 150 minutes of the session ($t = 17.15$, 24 *df*, $p < .001$). Thereafter, during both the remainder of the first session and the entire second session, the deprived Ss responded less frequently than the satiated Ss. During both operant sessions, bar pressing occurred most frequently at the outset of the session and then declined in negatively accelerated fashion. No differences were found between sexes or between animals destined for the SP and AP conditioning groups.

2. *Conditioning Sessions*

The middle panel of Figure 1 depicts the frequency of bar pressing during the six sessions in which responding was reinforced by light onset. The Ss showed a marked increase in responding during the first conditioning session ($t = 5.67$, 31 *df*, $p < .001$), the increase being independent of deprivation condition and sex. Response frequency rose more sharply in the AP group than the SP group however ($F = 8.29$; 1, 24 *df*; $p < .01$). After the initial conditioning session, the frequency of responding declined as a function of sessions ($F = 11.55$; 5, 120 *df*; $p < .001$) but remained significantly above the operant level through the sixth reinforced session ($t = 6.39$, 31 *df*, $p < .001$). The intersession decline in bar pressing was negatively accelerated and occurred at the same rate for all treatment combinations as assessed by orthogonal-polynomial tests of trend. As was true of unconditioned bar pressing, an analysis of 15-minute intrasession blocks of responding indicated that most responses were emitted during the early portions of each session. During conditioning, the deprived Ss responded less frequently than the satiated Ss ($F = 8.14$; 1, 24 *df*; $p < .01$). The AP group tended to respond more frequently than the SP group, especially under the satiated condition, although this comparison did not attain statistical significance ($F = 2.42$; 1, 24 *df*; $p < .20$).

3. Extinction Sessions

The total number of extinction responses for all treatment combinations is shown in the right panel of Figure 1. The omission of light onset following a bar press produced an abrupt decline in responding ($t = 6.39$, 31 *df*, $p < .001$). The drop in response rate was independent of deprivation condition and sex but was more pronounced in the AP group than the SP group ($F = 7.12$; 1, 24 *df*; $p < .025$). For all groups, responding decreased as a function of extinction sessions ($F = 7.41$; 2, 48 *df*; $p < .01$) but remained above the last operant session even during the third extinction session ($t = 2.32$, 31 *df*, $p < .05$). In extinction, as in the operant and conditioning sessions, most responding occurred within the initial 15-minute time blocks of each session. Food deprivation continued to lower responding throughout the extinction sessions ($F = 6.66$; 1, 24 *df*; $p < .05$). The light-reinforcement condition (AP *vs.* SP) produced no reliable differences in the frequency of bar-pressing responses in extinction.

D. DISCUSSION

Food deprivation affected the rate of bar pressing in a complex fashion. During the initial portion of the first operant session, food-deprived Ss responded more frequently than satiated controls. Thereafter, for the remainder of the operant sessions and throughout the conditioning and extinction sessions, food-deprived Ss responded less frequently. Considering first the operant sessions, an examination of previous research indicates that in those studies in which deprivation produced an increased response rate (2, 4), the animals had been under relatively mild deprivation schedules (two to 23-hours deprivation with one-hour access to food) for periods of one to 10 days prior to the beginning of testing. In those studies reporting a decrease in responding—Segal (6) and the present investigation—the deprivation was relatively severe (23-hours deprivation at 80 to 90 per cent of *ad lib* weight) for periods of seven to 21 days prior testing. It would appear, therefore, that mild deprivation increases the frequency of unconditioned bar pressing whereas severe deprivation depresses the operant level except during the initial phases of exposure to the test environment. The rapid decline of unreinforced responding in an environment devoid of nutrients is a phenomenon having obvious biological utility for highly deprived organisms.

With the introduction of light reinforcement, response frequency increased equally in both the deprived and satiated conditions. The absolute number of responses was less in the deprived condition however. The failure of depri-

vation to potentiate the light-reinforcement effect indicates that the Campbell-Sheffield hypothesis (1) is incomplete at best and that the Premack-Collier (5) reformulation of the hypothesis is clearly incorrect. According to the Campbell-Sheffield hypothesis, food deprivation "does not force activity, it . . . makes the animal more responsive to environmental changes (1, p. 320)." Since light onset was one of the environmental changes employed in the research that supported the hypothesis, the discrepancy between findings may simply indicate that activity as measured by movement in the Campbell-Sheffield tilting cage and by bar pressing in the operant test chamber are unrelated. Other investigators have previously reported disagreement among various response measures, all of which purport to measure "activity" (7). Premack and Collier have reformulated the hypothesis in more empirical terms as follows: "If the response level with *ad lib* maintenance is low, food deprivation produces little increment, but if the response level is high, food deprivation produces a substantial increment (5, p. 11)." As the response level in the present study increased with the introduction of light reinforcement, but the difference between the response levels of satiated and deprived *Ss* remained constant, the results are inconsistent with the revised hypothesis.

The stimulus-change condition (AP group) produced both a larger initial increase in responding at the beginning of light-reinforcement sessions and a more pronounced decrease in responding at the beginning of extinction sessions than the constant condition (SP group). During the conditioning sessions, the AP group consistently responded more than the SP group although the difference was not as pronounced as in earlier work (3). The present study differed from its predecessors in one respect—only the two upper-light positions were used whereas all four positions had been employed previously. As the distribution of illumination with the test chamber is quite similar from the upper-light sources but varies considerably between the upper- and lower-light sources, the diminished effect on response frequency in the present experiment is probably due to the decreased difference between test-chamber stimuli in the AP group. This interpretation is consistent with an earlier finding that an SP group which received light from a different source each session responded as frequently as the AP group (3). These findings, taken together, indicate that the pattern of test-chamber stimuli to which the animal exposes itself during light onset accounts, at least in part, for the increased responding during variable light reinforcement.

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EFFECTS OF MOTHER'S SHOCK TRAUMATIZATION IN INFANCY UPON OFFSPRING BEHAVIOR*

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A. PURPOSE

It is a well-documented fact that early experiences affect the behavior of animals tested in adulthood (1). Effects have typically been demonstrated through the application of learning tests and measures of emotionality to the traumatized animals themselves (4). A different type of question is whether other types of behavior, specifically maternal behavior, will also be modified by early experiences so that the behavior of offspring will show modifications similar to those observed in the mothers. For example, the issue might be whether offspring of rats which were traumatized in infancy will show behavioral changes and changes in learning ability in the direction of those shown in the mothers by which they were reared. The purpose of this study is to explore whether any differences can be discovered in the behavior of unstimulated offspring of rats that have been exposed to shock traumatization in infancy.

B. METHOD

About eight litters of Sprague-Dawley rats were exposed to shock traumatization in infancy. The shock box into which Ss were placed was a grid-floored chamber measuring $6\frac{1}{2} \times 4\frac{1}{2} \times 9$ inches. A constant-current inescapable shock of .2 ma. was applied for three minutes daily from Day 10 through Day 25 of life to one-half of each litter. The remainder of the litter was left untouched with the mother in the nest until weaning.

At 25 days of age, all animals were weaned, the males discarded, and the females housed together in community cages with six or seven animals to a cage. Upon reaching sexual maturity, the females were bred to a random sample of males from the colony. The procedure in breeding was to place two males with four females in a cage. The male rats were moved about from cage to cage each day and remained with females until pregnancy was obvious.

Following birth, all litters were cross-fostered to a mother other than the prenatal mother. Some litters were cross-fostered to mothers that had the

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same experience in infancy as the biological mother; some were cross-fostered to mothers that had received the opposite treatment in infancy. Consequently, there were four groups created by virtue of the combinations of mothers: S-S, S-NS, NS-S, and NS-NS (S = shocked and NS = nonshocked). Cross-fostering was accomplished by moving the mothers from one cage to another while leaving the pups undisturbed in the original cage. In the majority of cases, cross-fostering took place within 24 hours of birth between litters born on the same day. Two litters were cross-fostered within 48 hours of birth, two within 72 hours of birth. No experimental manipulations were carried out on the pups. Neither were the shavings changed in the nests after birth of a litter. At 25 days of age, the young rats were weaned, sexed, and placed in laboratory cages with littermates of the same sex.

At 70 days of age, a total of 168 rats, 96 females and 72 males equally divided among the four groups, was given two days of open-field testing. The open field was 30 inches square, painted flat black, with walls ten inches high. The floor was marked off into 36 five-inch squares by narrow white lines. A rat was placed in the lower-right corner of the apparatus and observed for three minutes. Squares traversed in the outer rim counted one point, those in the second rim two points, and the center four squares counted three. Each rat's score was determined by adding the scores assigned to the squares traversed for both days.

C. RESULTS

The data for open-field behavior are summarized in Table 1. The design was analyzed as a $2 \times 2 \times 2$ factorial with main effects of sex, prenatal mother, and postnatal mother. None of the main effects was significant by analysis of variance. However, a significant interaction ($F = 3.05, p = .05$) was found between sex and postnatal mother. The source of this interaction, as can be seen in Table 1, arose from the fact that males raised by NS mothers were less active in the open field than females raised by NS mothers whereas males raised by S mothers were more active than females raised by S mothers. In addition, a significant interaction ($F = 3.20, p < .05$) was obtained between the prenatal and postnatal mothers. Offspring born of and raised by mothers that had not been shocked in infancy were significantly less active than the other three groups. It can be observed in Table 1 that the other groups were approximately equivalent in mean activity score.

D. DISCUSSION

The results do not substantiate the position that the early experiences of the mothers modified their maternal behavior to the extent that differences

were discovered in the behavior of the offspring. Behavioral differences between groups of offspring could not be *directly* related to the early stimulation experiences of the mothers. Despite the fact that offspring behavior could not be related either to the prenatal or the postnatal mother alone, the significant interaction term between mothers led to the conclusion that different combinations of mothers resulted in differential behavior in offspring. In other words, implications regarding offspring behavior must take into consideration both constitutional (including physiological and biochemical elements) and environmental factors and the interaction of the two. It is noteworthy that Denenberg (2) obtained the same significant interaction term in a study similar to this, but with handling as the early experience. His NH-NH group,

TABLE 1
OFFSPRING ACTIVITY SCORES ON THE OPEN-FIELD TEST

Experience of prenatal mother	Experience of postnatal mother	Mean score		Total group (N = 168)
		Male (N = 72)	Female (N = 96)	
Shocked	Shocked	96.1	95.1	95.5
		> 94.7	> 103.0	
Shocked	Nonshocked	93.3	111.0	103.4
Nonshocked	Shocked	105.9	91.9	97.9
		> 86.1	> 89.7	
Nonshocked	Nonshocked	66.3	87.5	78.4

which would be similar to the NS-NS group in this study, also scored the lowest of all groups on mean activity score. The implication of this finding is that behavior as measured by the open-field test will not be adversely affected so long as rat pups are exposed, either prenatally or postnatally, to a mother that has received extra stimulation in infancy. The crucial combination in producing a decrement in behavior in the open field was the two-mother combination where both mothers were nontraumatized. There would appear to be a paradoxical effect of early traumatization inasmuch as nontraumatized rats scored significantly higher on mean activity score than animals exposed to inescapable shock (3), while offspring exposed only to NS mothers scored significantly lower on the same behavior than offspring exposed to S rats. This finding is unexpected and no ready explanation is apparent.

E. SUMMARY

Infant rats of several litters were exposed to shock traumatization, while a comparable number of littermates were not. The females were bred when they reached sexual maturity. Soon after birth the infants were cross-fostered to different mothers. At 70 days of age, all offspring were tested on an open-field

test. None of the main effects was significant, suggesting that effects of early traumatization are not directly transmitted from one generation to the next. However, a significant treatment-cross-fostering interaction term suggested that the two mothers in combination resulted in differential offspring behavior. Specifically, the offspring born of and raised by nonshocked mothers scored the lowest of all three groups.

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SPONTANEOUS HAND POSITIONS OF NEWBORN INFANTS*¹

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A. INTRODUCTION

Elicited grasping responses of very young infants have received the attention of many investigators (19, 24, 25, 28), but spontaneous hand positions in early infancy have been described more casually. The commonly held view has been that the hands of the infant are usually closed or fisted during the first several months of extrauterine life (14, 19, 30), although other hand positions are mentioned (12, 21), especially in connection with the tonic neck reflex in which the hand of the extended arm is frequently described and pictured as open (12, p. 240).

The normative work of Gesell and his associates has usually begun with infants of four weeks of age (13, 14, 15, 30); more often there has been general discussion rather than systematic presentation by these investigators of behavior at earlier ages (12). There is thus a need for a study of spontaneous hand positions of a large number of normal newborn infants, for whom exact ages, states, and conditions of observation are given.

More exact data on spontaneous hand positions have implications for infant developmental scales. Several of the scales give credit for "open" hands at 2-4 months of age, implying that hands are typically closed or fisted at earlier ages (3, 6, 13). Should systematic study demonstrate that open hands occur more frequently at earlier ages than has been supposed, especially among normal newborns, an error is being introduced into the scales, and the child under measurement is being credited with achievement of a function which he should have attained earlier. That some infants exhibit behavior during the first 10 days of life which appears in several developmental scales at later ages has been mentioned by Pratt (25).

Knowledge of the hand positions spontaneously assumed by newborn infants has even more important implications for theories of neurological development. At issue are the general question of the time at which the cerebral cortex

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becomes functional and the more specific question of the emergence of voluntary prehension, which is presumed to be under cortical control. Although the later stages of the achievement of voluntary prehension have been delineated in detail (5, 16, 17, 18), the early stages of its emergence are less well documented (35). The view that the elicited grasping responses, which are presumed to be controlled subcortically, must wane before voluntary prehension can emerge is based on the generalization that the young infant's hands are closed and must open before voluntary movement can take place. However, Halverson has challenged this view, pointing out that reflex and voluntary grasping have not been clearly differentiated and that they probably overlap (19).

Although the point in the developmental sequence at which the cerebral cortex becomes functional remains unknown (9, 24, 25), it seems probable that control emerges gradually and in different infants at different times, as pointed out by Conel (8, 9). Using multiple neuroanatomical criteria, he has compared the development of the cortex at birth and at 1 month of age, and has shown that at birth the cortical area controlling the nerves and muscles of the hands is second in development only to that controlling the upper trunk, shoulders, arms, and forearm. Although the area controlling the trunk, shoulder, and arm maintains its developmental lead, the area controlling the hands develops at a more rapid rate from birth to 1 month of age than any other portion of the cortex (9). If the relationship between morphological development of the cortex and function is to be clearly understood, it is essential to describe more precisely hand positions and movements along with other forms of behavior, spontaneous as well as elicited, and to document in more detail the changes which take place during the first few weeks of life after birth.

In the hope of throwing some light on the problem of the emergence of voluntary control by establishing a base-line description of the spontaneous hand positions and movements of the normal newborn infant, the present study was undertaken.

B. METHOD

The data consist of 30-second observations of the spontaneous hand positions of 360 newborn infants while asleep, awake, or crying. The infants were born in the New York Lying-In Hospital, and were judged normal by the examining obstetricians and pediatricians. They were delivered spontaneously or with the assistance of mid or low forceps. Their Apgar ratings were 7 or better (2). All weighed 2500 grams or more. Their courses in the nurseries were benign. Sixty of the infants were Negroes, 300 were white. Their

mothers were clinic patients of the hospital, middle-class in education and occupational background (the New York Hospital Clinic population includes a wide range of education and occupations, from lower to upper middle class).

Half the infants were selected from the M-3 nursery of the hospital, conducted on a modified "rooming-in" plan, for clinic and semiprivate patients. The other half were selected from M-1, a conventional nursery for clinic patients. An equal number of males and females, in a ratio of one Negro to five white infants, in each of five age groups (zero, 1, 2, 3, and 4 days of age), were observed in each nursery. One-third of the 360 infants were observed while asleep, one-third while awake, and one-third while fussing or crying. This procedure provided three stratified samples, one for each of the three states. The first 200 infants were selected at random; the rest were selected as required to complete each of the subgroups.

All the infants of this study were classified into three states which could be reliably distinguished one from the other—asleep, awake, or crying. Classifying them on the basis of observable states seemed more defensible than trying to relate hand positions to internal states without measuring them. For example, without measuring stomach contractions, beyond the scope of this study, it is difficult to ascertain how hungry a newborn infant is. The usual effort to control hunger is to relate the time of observation to the feeding schedule. This may not be as informative with respect to hunger in the newborn as has been assumed. Many infants have not yet established an observable hunger rhythm during the first few days of life. In most nurseries they receive their first feeding at variable periods of time after birth. The feeding schedules of the two nurseries from which the infants of the present study were selected varied, and that of one nursery was far more rigid than the other. While it seems reasonable to assume that many of the crying infants were hungry, infants are known to cry for other reasons as well (1).

Thus the focus was upon hand positions *within* states, and not upon the frequency or duration of the states themselves. Originally the three states were broken down into more refined categories suggested by the work of others (10, 32), but these refinements proved impractical.

1. *The Final Classification*

The classifications used are as follows:

a. *Asleep.* The infant's eyes are closed and he is generally quiet, although he may make slight movements of face and body. Usually he appears to be in a relaxed state, and he is not sucking vigorously, fussing, or crying.

b. *Awake.* The infant's eyes are open and frequently fixating briefly on one

object or another. He is usually making at least slight movements of face and body, and sometimes he is very active. He is not fussing or crying.

c. *Crying.* Fussing and crying are considered one and the same, as the exact second at which fussing becomes crying is difficult to ascertain. The infant is usually moving both his head and body, and he is vocalizing in a manner that suggests protest or discomfort rather than contentment.

The infants were observed in their own cribs, loosely swaddled, with their hands exposed to view. Only infants lying in a supine position were included, since preliminary study revealed that the hand positions of infants lying prone were influenced in variable degrees by contact with the surface, and were not comparable with those of infants who were supine. Before an infant is able to roll over independently, and especially when he is hampered by his clothing, he tends to remain in the position in which he has been placed by his mother or nurses, who have variable ideas as to which position is best for him and in which he is most comfortable. Marquis has reported that the most commonly assumed position throughout the first year is supine (22) even while sleeping.

The infants were not touched or in any manner stimulated during the 30-second periods of observation which were timed with a stop watch. Identifying data—the positions of the infant's head, body, and arms—and his state were recorded. Observations on infants who changed state during the 30-second intervals were discarded. Changes of state within observation periods occurred infrequently, approximately once in 30 observations.

2. *Hand Positions*

The hand positions observed and recorded during the 30-second intervals of each observation are defined as follows:

a. *Tightly fist.* The fingers are flexed at the second joint and usually at the first joint as well. The tips of the fingers are pressed against the palm of the hand and are sometimes hidden from view. Occasionally pressure is shown by the whiteness of the knuckles or tips of the fingers under and around the nails. To classify as tightly fist, three of four fingers must be in the position described above. When the thumb is inside the fist, the fingers are pressed against the thumb rather than the palm.

b. *Loosely fist.* The fingers are flexed at the second joint and usually at the first joint as well. The tips of the fingers are resting lightly on the palm or are held barely off the surface of the palm. When the thumb is inside the fist, the fingers curl lightly about the thumb. To classify as loosely fist, three of four fingers must be in the position described above.



FIGURE 1
ILLUSTRATIONS OF HAND POSITIONS

- A. Tightly fisted, both hands
- B. Loosely fisted, both hands
- C. Partly open, both hands
- D. Open, both hands

c. Partly open. The finger tips are farther from the palm than in the loosely fist position. The fingers are held in a position ranging from the loosely fist position to, and including, a half-open position, regardless of the position of the thumb. To classify as partly open, three or four fingers must be in the position described above.

d. Open. The hand is more than half-open, and the fingers are held in slight or moderate flexion. Originally an additional classification of fully extended fingers was included, but this classification was so infrequently used that "extended" was combined with "open."

Provision was made in scoring for the possibility of two fingers falling into one category and two in another, the more open position best characterizing the impression of the hand. However, this actually occurred only once, between open and partly open categories, with the hand classified as open.

The four static hand positions as defined are illustrated in Figure 1.

In order to establish the reliability of the observations, the hand positions of an additional 60 infants, selected in the same manner as those of the main sample except that they were all from the M-1 nursery, were scored independently by two observers.

C. RESULTS

Ninety-five per cent of the 60 paired observations were in agreement as to hand positions. There were no disagreements as to state. No significant differences in hand positions were revealed between the infants in the two nurseries, between males and females, or between Negro and white infants. There were slightly more females of both races with moving hands, and Negro infants of both sexes held their hands in relaxed positions slightly more often than white infants. Similar tendencies were reported by Gatewood and Weiss (11) but found statistically insignificant by Pratt (26). Over the period of observation, zero to four days, there were no consistent trends in hand positions with age.

Table 1 shows the hand positions of the infants in each of the three states. It is at once apparent that crying infants almost always had one and usually both hands in motion. They moved their hands from loosely fist to partly open or open positions and then reversed them, only occasionally pausing with the hands in the more extreme positions.

The thumb moved less freely than the fingers and often remained in the palm. A more detailed description of the nature of these movements would require the use of a moving picture camera.

Tightly fist hands were seen infrequently in any of the states. As might

be expected, infants observed while asleep had their hands in relaxed positions (loosely fisted, partly open, and open) more often than infants observed while awake, and the latter were more often observed with hands moving.

Table 2 gives the frequencies and percentages of the individual hand posi-

TABLE 1
SPONTANEOUS HAND POSITIONS OF 360 NEWBORN INFANTS OBSERVED
WHILE ASLEEP, AWAKE, OR CRYING

Position of hands		Asleep	Awake	Crying
Both hands in the same position				
Moving		5	34	105
Tightly fisted		2	3	1
Loosely fisted		23	11	0
Partly open		26	15	0
Open		13	4	1
Hands in different positions, one moving				
<i>Left</i>	<i>Right</i>			
Moving	Tightly fisted	3	4	0
Moving	Loosely fisted	1	3	2
Moving	Partly open	0	2	4
Moving	Open	0	2	0
Tightly fisted	Moving	0	1	0
Loosely fisted	Moving	3	1	2
Partly open	Moving	0	4	2
Open	Moving	0	4	2
Hands in different static positions				
<i>Left</i>	<i>Right</i>			
Loosely fisted	Tightly fisted	2	3	0
Partly open	Tightly fisted	1	4	0
Open	Tightly fisted	4	3	0
Partly open	Loosely fisted	11	8	0
Open	Loosely fisted	5	0	0
Open	Partly open	6	5	0
Tightly fisted	Loosely fisted	0	1	0
Tightly fisted	Partly open	1	1	0
Tightly fisted	Open	0	0	0
Loosely fisted	Partly open	5	4	0
Loosely fisted	Open	3	1	0
Partly open	Open	6	2	1
Total number of infants observed		120	120	120

tions of the 120 infants observed while asleep and the 120 infants observed while awake. The most frequently observed hand position of sleeping infants was partly open (34 per cent), followed by loosely fisted (32 per cent), and open (21 per cent). The total amount of fisting (tightly fisted and loosely fisted categories combined) was 38 per cent of the 240 hands observed.

The most frequently observed hand position of infants who were awake

was moving (37 per cent), followed by partly open (25 per cent), and loosely fisted (18 per cent). The total amount of fisting was 28 per cent.

Moving hands could be classified as both fisted and open. If the category "moving" is excluded, 91 of the 223 remaining hands observed of sleeping infants, or 41 per cent, were tightly or loosely fisted, with five-sixths of the fisted hands in the loosely fisted category. Among infants observed while awake, with the much larger number of hands in the "moving" category

TABLE 2
INDIVIDUAL HAND POSITIONS OF INFANTS OBSERVED WHILE ASLEEP AND AWAKE

Hand positions	Asleep		Awake	
	N	%	N	%
Moving	17	7	89	37
Tightly fisted	15	6	23	10
Loosely fisted	76	32	43	18
Partly open	82	34	60	25
Open	50	21	25	10
Total number of hands observed	240	100	240	100

TABLE 3
FISTING IN RIGHT AND LEFT HANDS OF INFANTS WHOSE
HANDS WERE HELD IN DIFFERENT POSITIONS

Degree of fisting	Asleep		Awake	
	Left	Right	Left	Right
Tightly fisted*	1	10	3	14
Loosely fisted	11	17	6	11
Total fisting	12	27	9	25

* In two sleeping infants and three infants who were awake, the right hand was tightly fisted and the left hand was loosely fisted; these have been counted as exhibiting more fisting in the right hand.

excluded, 66 of 151 of the remaining hands, or 44 per cent, were tightly or loosely fisted, with two-thirds in the loosely fisted category. Thus, less than one-half the hands observed in any static position in infants who were awake or asleep were fisted to any degree, and a much larger proportion of these were loosely rather than tightly fisted in both states.

Table 3 compares the amount of fisting in the right and left hands of infants observed while asleep and awake, when their hands were held in *different* positions. Fisting of the right hand was consistently more frequent. If, in the absence of general agreement as to the existence of laterality in the newborn (7, 21, 24), we assume that half the fisting observed should be in the right hand and half in the left, and we then compare the observed frequencies of right-handed fisting in this study with the hypothetical frequency of 50 per

cent, the greater amount of fisting of the right hand is significant in both states. [$p = .01$ for infants observed while awake; $p = .02$ for infants observed while asleep, *two-tailed test* (23, p. 49).]

D. DISCUSSION

The discrepancy between the findings of the present study and the commonly accepted generalization from the earlier studies concerning the prevalence of closed or fisted hands among newborn infants may have several explanations. It may reflect varying methods of study, differences of definition of "fisting," differences in the ages of the subjects, or a genuine change in infant behavior.

Great care was exercised in this study to secure an adequate sample of behavior in each of three clearly differentiated states. Only healthy full-term infants, who did not have difficult births, of middle-class parentage, an equal number of males and females in each of five age groups and in each of two nurseries, were included; and the same racial composition was maintained in each group. A larger number of infants were observed than in most previous studies. Since the conditions of observation have rarely been described in the earlier investigations, whether or not the differences result from varying techniques of observation cannot be ascertained. In this study the classification of hand positions has been carefully stated.

The limitation of age groups to exactly 24 hours, for each day from birth through 4 days, deserves special mention, since wider age groupings or unspecified ages were included in earlier reports. Varying definitions of "new-born" and "neonate" in different reports have added to the confusion. During the period of extremely rapid development immediately following birth a difference in age of a few days could make the results of two studies incomparable.

If there is a period when closed or fisted hands prevail before or after that included in the present study, this should be documented, not accepted on faith or by projection. The existence of such a period seems unlikely on the basis of continuing observation at New York Hospital of premature infants and infants seen in the well-baby clinics up through 3 months of age. If there is not a period where closed hands are predominant, the item "open hands" has little relevance in tests of normal development during the first six months and should be removed from the scales. Persistently fisted hands beyond 6 months of age may be an indication of mental retardation, as suggested by Wagoner (33); perhaps it has significance in this respect at even earlier ages.

Changes in results based on refinements of method are to be expected as study of the behavior of newborns proceeds. However, the discrepancy reported here may be at least partially due to a change in infant behavior rather than to improved methodology. This possibility gains credence from the fact that a generation has passed since the publication of most of the earlier studies. In the interval there have been many improvements in the prenatal care of mothers, in obstetrical practices, and in the nursery care of newborn infants. Conspicuous among these changes are the more conservative use of drugs during labor and delivery and the availability of better drugs. Infants born in the 1960s may actually be in better condition during the first few days of life than those who were born in the 1930s. Brazelton (4) has shown that the infants of mothers who have been heavily sedated during labor and delivery are less responsive for several days after birth than those of mothers who have received a minimum of drug therapy. At New York Hospital mothers receive minimal doses of the milder drugs except for extraordinary circumstances, in which case their infants would not have been included in this study. Therefore the infants of this study might be expected to be responsive when awake and relaxed in sleep, and their hands might be expected to be found in a wide variety of positions including moving while awake and loosely fisted and partially open when asleep. Changes in the philosophy concerning many aspects of medical care of mother and child in addition to changes in drug therapy may have resulted in more advanced behavior in some infants during the first few days of life.

A closed or fisted hand may be a tense hand or a hand which is loosely curled and lacking in tension. To date no satisfactory method of measuring tension in an infant's hands without destroying spontaneity has been devised. Changes in tension in the hands of newborns are often observable, however. For example, when an infant begins to suck from bottle or breast he often closes his hands tightly, as shown by the whitening of his knuckles. After sucking has become rhythmical and hunger or thirst has been somewhat abated, the fingers may relax and open and the hand fall away from the bottle or breast. Renewed vigorous sucking may be accompanied by the closing of the hands again. This suggests that some of the fisting seen in the newborn results from normal effort. Excessive and persistent tension in the hands may indicate temporary physical discomfort or illness, the presence of a motor handicap, or severe emotional disturbance in some infants.

The unexpected findings of a statistically significant difference in the amount of fisting favoring the right hand is more difficult to explain and requires further study. It calls into question once more the assumption of some

authorities that all the behavior of the newborn is reflexive in nature. Most reflexes present in infants at birth are symmetrical, and their symmetry is often considered a reassurance as to their normality. An exception is the tonic neck reflex which is reported to be variable, but, according to Gesell is more often found on the right side (12). Marquis has reported that infants usually prefer to lie on the right side throughout the first year (22). When the infant is observed in a tonic neck reflex with his right arm extended, the hand is usually open although not invariably so. The grasping responses have been reported to be equal in strength in both hands or slightly stronger in the left (19, 27). In some studies on motility in the arms of newborn infants, greater motility in the right arm has been reported; in others no difference has been found (29, 31, 34). If all fisting of the hands of newborns is reflexive, it would seem likely that more would be found in the left hand, assuming that the hand must open before voluntary fisting can occur. The results of this study are in the opposite direction. On the other hand, the findings of the present study support Halverson's view that all movements of the hands of newborns may not be reflexive, that reflexive and voluntary movements are not clearly differentiated and probably overlap. Thus it may be that some of the fisting seen in newborns is the beginning of the long struggle for voluntary control in the more advanced infants.

There has never been a satisfactory explanation of the fact that most adults in most cultures are right handed. It has usually been stated with more confidence than data that laterality does not exist at birth, and some authors go so far as to offer an entirely environmental explanation of the emergence of right handedness. Most investigators consider laterality to be partially genetically determined but its expression influenced by environment. If laterality does exist from birth, a purely environmental explanation is clearly untenable. More refined morphological studies and electroencephalography applied to the cerebral cortex of newborn infants may reveal slight differences between the hemispheres which could account for laterality and signal its emergence in early infancy. It is also still possible that the dominance of the left hemisphere in laterality and in the development of language in most persons results from the exercise of these functions rather than precedes them. The period when cortical control of the hands emerges may be earlier than has been previously assumed.

E. SUMMARY

The hand positions of 360 supine infants zero-4 days of age, were observed for 30-second intervals, one-third of the infants in each of three states:

asleep, awake, and crying. Crying infants almost always had their hands in motion. Sleeping infants most often had their hands in a relaxed partly open position. Those observed while awake had their hands moving slightly more often than in relaxed or fisted positions.

Fisting to some degree was seen in only about one-third of the hands of sleeping infants and in only slightly more than one-fourth of the hands of infants who were awake. When the two hands of sleeping and waking infants were in different positions, a significantly greater than 50 per cent of the fisting occurred in the right hand of both groups.

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ACTIVITY AND EXPLORATION AS A FUNCTION OF AGE AND DEPRIVATION*

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A. INTRODUCTION

The principal function of exploration is "to afford access to environmental information that was not previously available (3, p. 79)." Implicit in this definition is the idea of an animal moving about within a novel or familiar environment and examining its characteristics. However, in most experiments with rats as subjects it would be impossible to judge the extent of exploration because the principal measure, locomotion, is not necessarily related to investigatory behavior and, in fact, could be inversely related under certain conditions: e.g., while the animal is in a highly activated or fearful state. In the present experiment, exploration was operationally defined for rats as sniffing in the bright portion of a field when there was the possibility of retreat into a dark area.

Investigations of behavioral changes as a function of deprivation and age are rare (2, 9) and senescent animals (i.e., > 24-months old) have not been tested in any such experiment. Two recent reports of rat open-field behavior suggest age-related decrements in activity and exploration (7) as well as emotionality and locomotion (14). Again, no senescent rats were tested in either experiment. The present experiments were designed to determine the specific relations of age and deprivation to exploratory behavior and locomotion of male albino rats over the age range of 1.5 to 24 months. By utilizing tests other than locomotion it was possible to determine the relations of age and deprivation to locomotion in a simple or complex open field and sniffing in the bright portion of an open field. On the basis of preceding preliminary experiments¹ a number of specific predictions was possible. The results of these

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¹ These hypotheses were based upon the two papers cited as well as the results of several other unpublished experiments. EPA, 1962, Open field behavior as a function age, drive and level of sensory stimulation (a), APA, 1962, Age and barrier height as determinants of exploration (b). Summaries of these reports will be made available upon request to the writer.

experiments differed from the expected in that adolescent rats (about 2-months old) were found to engage in more freezing and less exploration than rats 1- or 3-months old. In fact, under some conditions number of exploration responses of adolescent and older male rats did not differ. Where a prediction is based on specific unpublished data (i.e., Experiment a or b), reference is placed at the end of the sentence.

1. Hypotheses

1a. Free exploration, defined as time spent within the bright area of a field, would be an increasing function with increasing deprivation.

1b. As a function of trials free exploration would increase for adolescent animals, would remain constant for 12-month-old animals and would decrease for aged animals (Experiment b).

2. No differences would be expected in exploration between adolescent and mature or senescent rats (Experiment a).

3. Activity would be a decreasing function with increasing age. However, deprivation would interact with age in such a way that the activity of young deprived animals would be reduced while that of old deprived animals would be increased in comparison with *ad lib* controls (Experiment a).

4. No differences would be obtained in barrier jumping and activity in the complex field between adolescent and senescent rats (Experiment a).

5. Barrier jumping and activity in the complex field would be an increasing function of amount of deprivation.

6. Exploration would be a decreasing function with increasing age for 3-, 12-, and 24-months-old rats (Experiment b).

B. METHOD

1. Subjects

Young (Sprague-Dawley), mature (Sprague-Dawley) and senescent (Wistar) male albino rats were subjects. The degree of dietary deprivation was predetermined by an experimental design for the determination of the biochemical effects of deprivation by another section of the Gerontology Branch. Because the data were consistent with other research findings within the Animal Behavior Section, and specific hypotheses could be formulated on the basis of earlier work, meaningful relations were obtained. Although the oldest group were Wistar rats, in work within this laboratory no open-field differences have been obtained between male Sprague-Dawley and male Wistar rats over the age range of 1 to 24 months.

All animals were housed individually in Wahmann (Baltimore, Maryland) rat cages ($7 \times 10 \times 7$ inches) and were not handled prior to the experiment. Lights within the room were on from 6 am to 6 pm. Deprivation was begun at age 1 month (Group 1), 10 months (Group 2, estimated age of Sprague-Dawley retired breeders), or 19 months (Group 3) for the three age groups. Food was *ad lib* and 50 per cent or 25 per cent of normal daily ingestion. Amount for the youngest group was determined by nondeprived controls of the same age, while the food of the older groups was measured for each individual by means of 24-hour samples of ingestion prior to deprivation. Because senescent animals were unable to tolerate the extreme level of deprivation, none were deprived at the 25 per cent level. The result was a total *N* of 74

TABLE 1
PERCENTAGE OF *Ad Libitum* WEIGHT AND NUMBER OF SUBJECTS IN EACH GROUP
AT THE START OF EXPERIMENT 1

Age in months	Percentage of food					
	100%		50%		25%	
	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>
1.5	100	(10)	80	(10)	60	(9)
10.0	100	(10)	80	(10)	60	(8)
22.0	100	(9)	60	(8)		

(see Table 1). Experiment 2 utilized only the *ad lib* nondeprived and 50 per cent-deprived groups (due to deaths within 25 per cent groups), six weeks after Experiment 1, when the subjects were about 3-, 12- and 24-months old. Weights of all deprived animals had dropped to about 60 per cent of normal at this time.

2. Apparatus

An open field 25×25 inches square and 18 inches high was the test chamber. In the center of one side was an opening five inches wide and eight inches high which allowed access to a recessed dark area of 40 square inches ($5'' \times 8''$). The opening to the dark area could be sealed by means of a tight-fitting block of wood. Also, wood barriers were constructed which would divide the area into four quadrants. Windows (4×4 inches, either 2.5 or 5.0 inches above the floor) placed at the center of each quadrant barrier allowed the animal access to all four areas after placement in one quadrant.

3. Procedure

Two experiments were conducted during different periods of the lengthy deprivation period. Experiment 1 tests allowed measurement of two principal

kinds of behavioral response: exploration and locomotion. The operation defining exploration was time sniffing outside of a dark hiding area within a comparatively bright open field. Activity measures were of two kinds: (a) number of quadrants entered within a simple large open field, (b) total number of barriers jumped and related activity (quadrants traversed within each isolated quadrant) within a complex open field. Experiment 2 defined exploration in the same manner, but used a technique to obtain additional information concerning behavioral responses during testing.

Due to the differences in time of initiation of deprivation, the old animals had a longer period of deprivation experience. Also, due to deaths within groups, equal numbers of animals were not always present for each age. For these reasons and because earlier data were available to allow fairly specific predictions, simple randomized designs were used in lieu of complex analyses of variance. Experiment 1: Ss were run on five tests, one each day for five days, at approximately 24-hour intervals between the hours of 6 and 9 am. Feeding time was from 9 am to 11 am.

Day 1, Test 1—Ss were placed within the open field and allowed to enter the dark hiding area. The time (seconds) which the animal spent in exploring outside of the dark area was recorded for a three-minute period.

Day 2, Test 2—Activity scores were obtained by measuring number of quadrants traversed within the bright portion of the field for a three-minute interval. Access was not allowed to the dark area, which was blocked by means of a tight-fitting wooden barrier.

Days 3 and 4, Tests 3 and 4—For these tests barriers were used which divided the box into four quadrants. Windows at two heights allowed the animal to enter quadrants other than the one in which he was initially placed by climbing through the window. Groups were split so that one-half of each group were tested at the 2.5 inches height one day and the 5.0 height the following day. The other Ss were tested in the reverse order. Tests lasted for two minutes on each day. Scores of number of quadrants entered (by climbing through the window) and total activity (quadrants traversed) within each of the four sections were obtained.

Day 5, test 5—Ss were placed within the open field and allowed to enter the dark hiding area. The time (seconds) which the animal spent in exploring outside of the dark area was recorded for a three-minute period.

Experiment 2: All subjects were run for one 10-minute trial within the open field with access to the dark recessed area. Scores were obtained for periods of sniffing, grooming, or lying without sniffing, as well as for whether the animal was within the dark or bright area of the field. One hundred scores

were obtained for each subject, one for every six seconds over the 10-minute test period. This test was exactly the same as Test 1 of Experiment 1 except that the test duration was longer and a time-sample procedure was used to estimate time outside of the dark area and to obtain additional behavioral measures. The primary purpose of this test, which was developed after completion of Experiment 1, was to show clear-cut age differences in exploration due to a hypothesized increase in such behavior in the youngest group in comparison with the two older groups.

C. RESULTS

1. Experiment 1

Tests 1 and 5—Exploration was greater for deprived animals at all age levels on both Trial 1 on Day 1 and Trial 2 on Day 5 (Table 2). The form of

TABLE 2
TESTS OF SIGNIFICANCE FOR DIFFERENCES IN EXPLORATION BETWEEN DEPRIVED AND NONDEPRIVED RATS AT EACH AGE LEVEL (EXPERIMENT 1)

Age in months	Trial 1	Trial 2
1.5	$F = 33.08, df = 2/26, p < .01$	$F = 6.50, df = 2/26, p < .01$
10.0	$F = 32.14, df = 2/25, p < .01$	$F = 29.64, df = 2/25, p < .01$
22.0	$t = 5.18, df = 15, p < .01$	$t = 1.07, df = 15, p > .10$

the function was consistent for all groups on both trials with the exception of young 50 per cent-deprived subjects who explored somewhat less ($p > .05$) than *ad lib* controls (see Figures 1, 2, and 3). This finding is consistent with barrier-jumping data on the two days following Trial 1. Also, although aged deprived animals engaged in more exploratory behavior on both Trials 1 and 2 in comparison with *ad lib* controls, differences were small and not statistically significant on Trial 2.

Young nondeprived- and 50 per cent-deprived animals engaged in significantly more exploration on Trial 2 in comparison with Trial 1 (non-deprived, $t = 1.96, df = 18, p < .05$; 50 per cent deprived, $t = 4.63, df = 18, p < .01$; one-tailed tests), while 75 per cent deprived, although having higher scores on Trial 2, did not explore significantly more. No significant differences were obtained between the three mature groups, but *t*-tests indicated significant decreases in exploration for the oldest age groups (non-deprived, $t = 1.76, df = 16, p < .05$; 50 per cent deprived, $df = 14, t = 4.24, p < .01$; one-tailed tests).

For *ad lib* animals, age was not a variable significantly affecting exploratory behavior. At the three ages tested *F* tests were nonsignificant on both Trials

1 and 2. Aged 50 per cent-deprived Ss, because of their longer period of deprivation, were at the same weight as 25 per cent of *ad lib* young and mature animals. On this basis these three groups were compared for age differences on Trials 1 and 2. Although differences were not significant on Trial 1, Trial 2 differences were highly significant ($F = 17.25$, $df = 2/22$, $p < .01$), largely due to a drop in mean scores for the oldest age group.

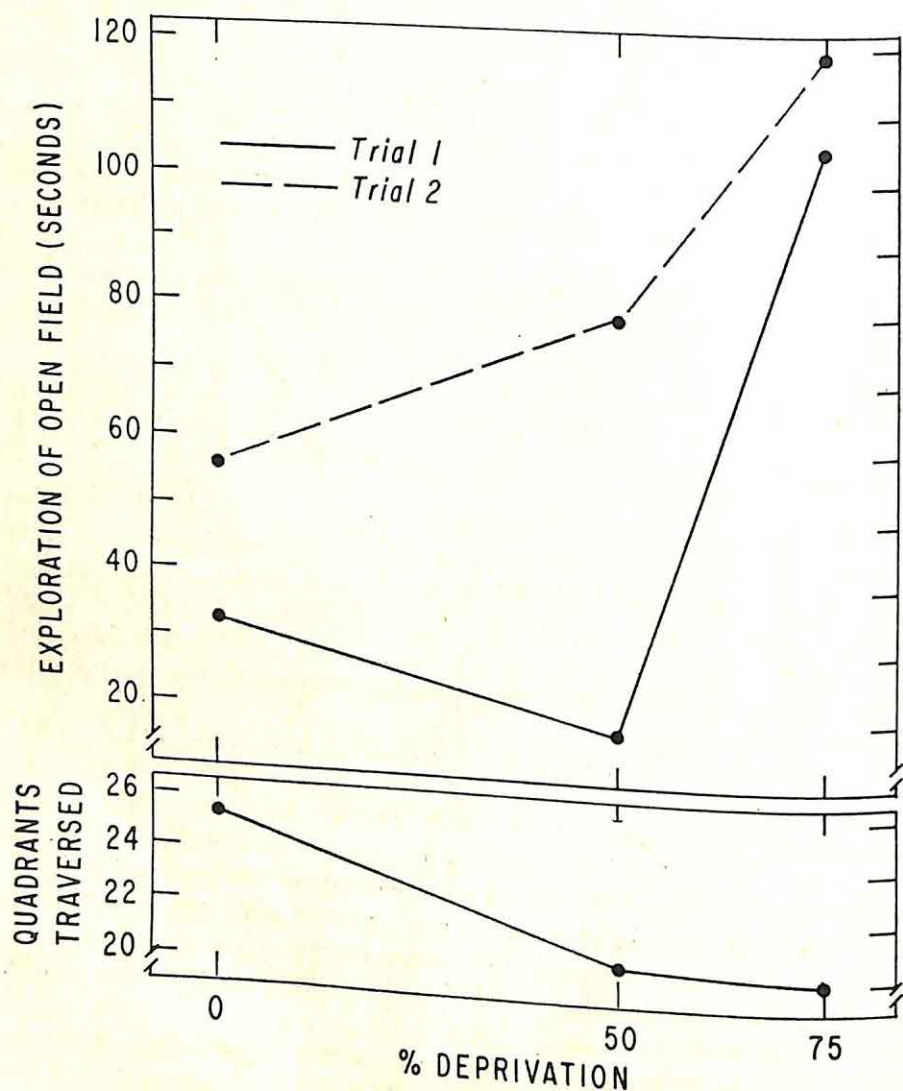


FIGURE 1
ACTIVITY AND EXPLORATION OF YOUNG MALE ALBINO RATS

Test 2—In general, activity (quadrants traversed) was a decreasing function with increasing age. While the results were similar for *ad lib* and deprived groups, no specific comparisons were made concerning activity change with age in deprived groups because of differences in deprivation experience. Significant differences were obtained for all age comparisons between *ad lib* groups

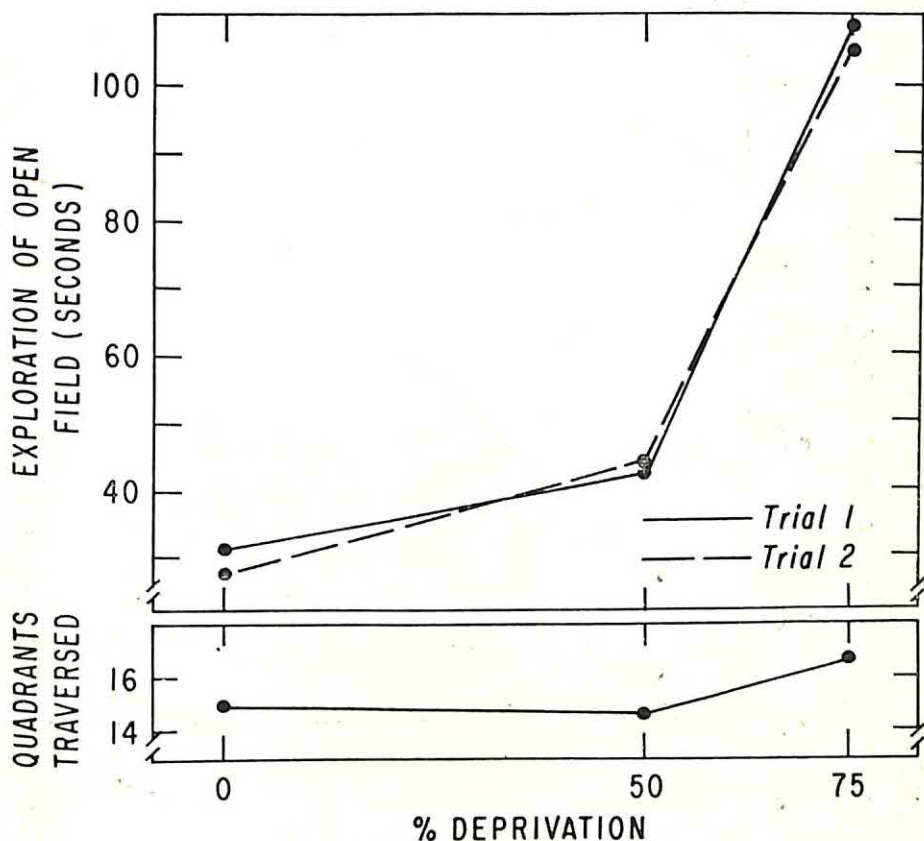


FIGURE 2
ACTIVITY AND EXPLORATION OF MATURE MALE ALBINO RATS

(young *vs* mature, $t = 4.14$, $df = 18$, $p < .01$; young *vs* old, $t = 7.13$, $df = 17$, $p < .01$; mature *vs* old, $t = 2.27$, $df = 17$, $p < .01$). Comparisons between groups of the same age revealed that young deprived animals were less active than young *ad lib* controls (*ad lib vs* 50 per cent, $t = 2.17$, $df = 18$, $p < .05$; *ad lib vs* 25 per cent, $t = 2.42$, $df = 17$, $p < .05$). Although no differences were obtained between mature deprived groups and the *ad lib* controls, senescent deprived animals were significantly more active in com-

parison with *ad lib* controls ($t = 2.72$, $df = 15$, $p < .05$). Comparisons of locomotor activity level and exploration may be made at each age level in Figures 1, 2, and 3.

Tests 3 and 4—Barrier jumping and activity were a function of deprivation. In general deprived Ss at all ages were more active and jumped more barriers in comparison with *ad lib* controls (Figure 4). However, results for young

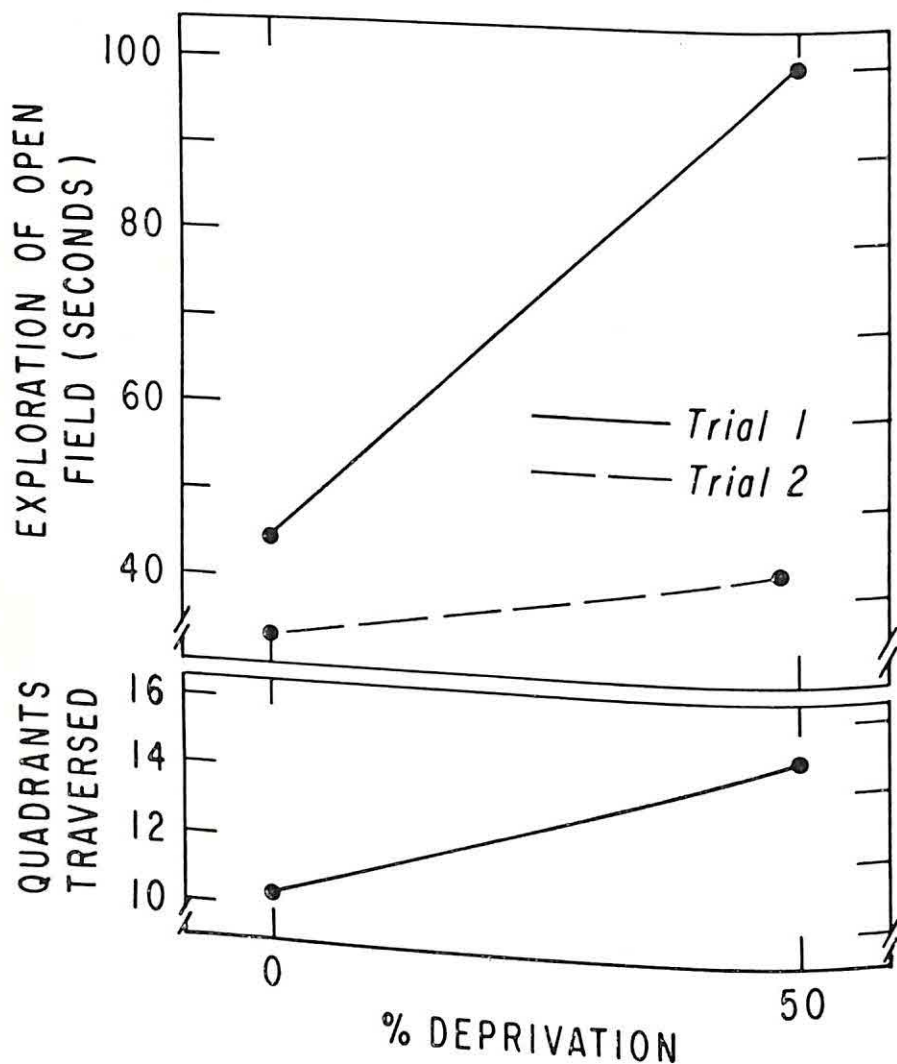


FIGURE 3
ACTIVITY AND EXPLORATION OF SENESCENT MALE ALBINO RATS

groups were similar to those obtained during Tests 1 and 5 for exploration. That is, no differences were obtained between *ad lib* and 50 per cent of *ad lib* groups for either the activity or barrier measure. In fact, no animal of either of these young groups jumped a single barrier. In contrast, young Ss fed 25 per

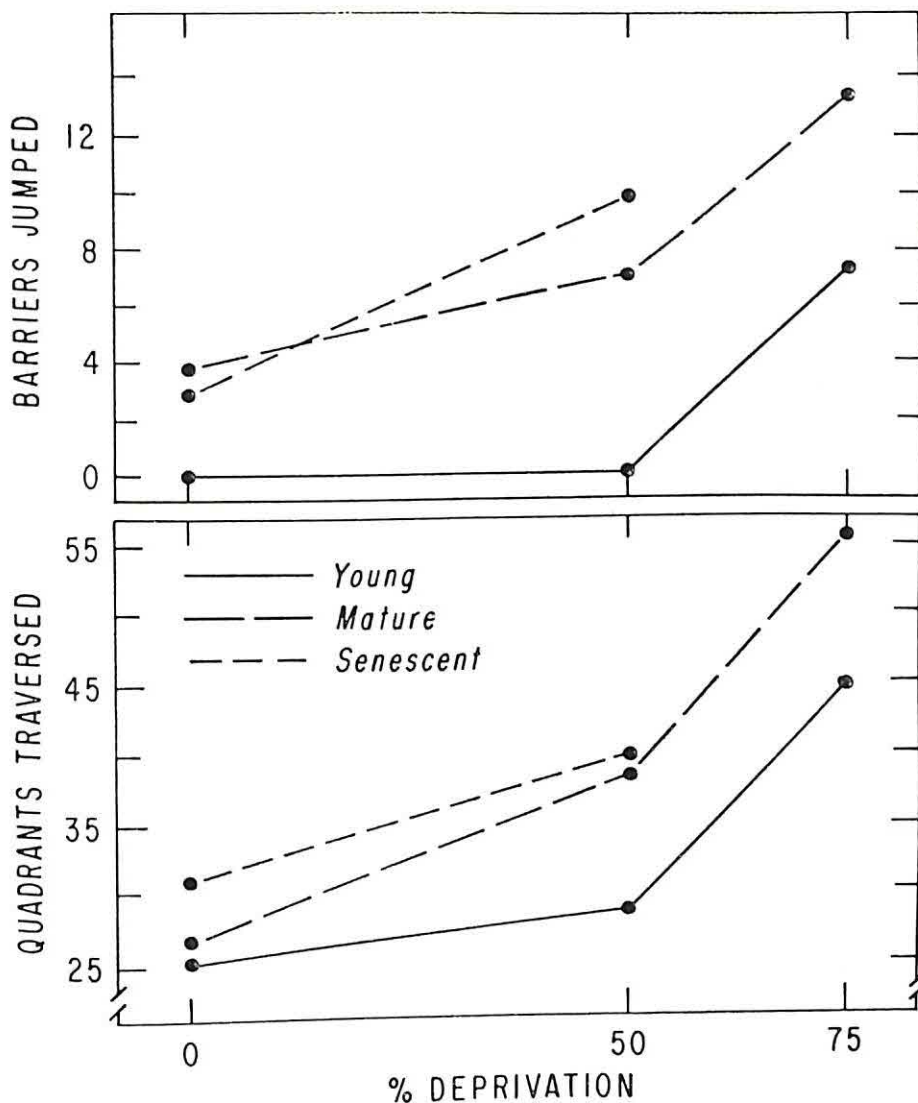


FIGURE 4
BARRIER JUMPING AND RELATED ACTIVITY OF YOUNG, MATURE AND
SENESCENT MALE ALBINO RATS

cent of *ad lib* all jumped at least one barrier and were significantly more active than *ad lib* (100 per cent) controls under these conditions ($t = 3.73$, $df = 17$, $p < .01$). Mature deprived animals jumped more barriers (100 per cent *vs* 50 per cent, $t = 1.92$, $df = 18$, $p < .05$; 100 per cent *vs* 25 per cent, $t = 4.92$, $df = 16$, $p < .01$; one-tailed tests) and were more active (100 per cent *vs* 50 per cent, $t = 3.91$, $df = 18$, $p < .01$; 100 per cent *vs* 25 per cent, $t = 9.93$, $df = 16$, $p < .01$) in comparison with *ad lib* controls. Also deprived senescent *Ss* jumped more barriers ($t = 5.11$, $df = 15$, $p < .01$) and were more active ($t = 2.33$, $df = 15$, $p < .05$) than *ad lib* old control animals. Although tests were not made of age differences at differing levels of deprivation due to scores of zero and deprivation-duration differences, it is obvious (Figure 4) that under these test conditions increasing age is not related negatively to barrier jumping and activity for these particular age groups.

2. Experiment 2

For *ad lib* animals exploration was a decreasing function with increasing age (Figure 5). Differences among the three groups in mean periods of exploring the bright area of the field were highly significant ($F = 9.34$,

TABLE 3
TESTS OF SIGNIFICANCE FOR DIFFERENCES IN EXPLORATION AND LYING OR GROOMING
BETWEEN DEPRIVED AND NONDEPRIVED RATS AT EACH AGE LEVEL

Age in months	Exploration	Lying or grooming
3.0	$t < 1.00$	
12.0	$t = 3.23$, $df = 18$, $p < .01$	$t = 3.12$, $df = 18$, $p < .01$
24.0	$t = 4.06$, $df = 15$, $p < .01$	$t = 5.91$, $df = 18$, $p < .01$ $t = 5.21$, $df = 15$, $p < .01$

$df = 2/26$, $p < .01$). This was principally due to the much higher mean score of the youngest group, in comparison with the two older groups. In addition, nonexploratory responses of lying or grooming ($L + G$) were tabulated and were found to be an increasing function with increasing age ($F = 4.42$, $df = 2/26$, $p < .05$). No differences were found between deprived animals of the three age groups for exploration or lying or grooming. In general, deprived animals engaged in more exploration and less lying or grooming than *ad lib* controls at all ages. With one exception t -tests were all at the .01 level of significance (Table 3).

D. DISCUSSION

The present data indicate that locomotion in a simple open field is a complex function of age and deprivation, so that young deprived rats tend to reduce

locomotor activity in comparison with young controls, while aged deprived animals engage in more locomotion than aged controls. Such findings are probably due to a more vigorous examination of the interior and contents of the field by all deprived animals: i.e., increased exploration. Comparative rates between deprived and nondeprived animals are dependent upon locomotion under *ad lib* conditions. For example, Montgomery (10) found a reduction of activity for deprived 100-day-old female rats, which are normally more highly

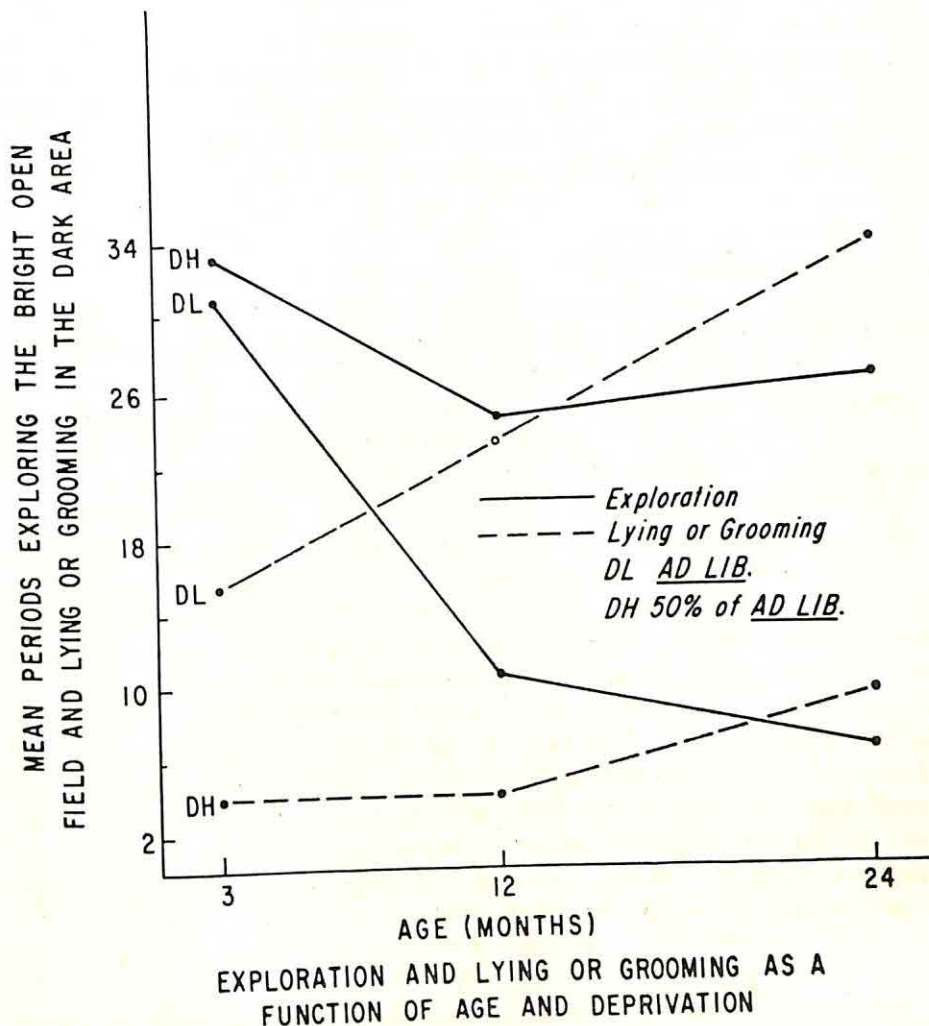


FIGURE 5

EXPLORATION AND LYING OR GROOMING AS A FUNCTION OF AGE AND DEPRIVATION

active than males or older animals (e.g., 14). However, in the present experiment, activity of deprived animals, measured during successive examinations of identical quadrants of a complex field, was positively related to other measures of exploration and gives support to the findings of Adlerstein and Fehrer (1). The latter investigators found a 50-75 per cent increase in activity of deprived rats in a complex, asymmetrical maze.

Relations of locomotor activity between satiated and deprived groups of animals have typically been difficult to determine from the literature. Defined in terms of activity within the maze, food or thirst deprivation reduced the amount of "exploration" in the data of Montgomery (10) and other studies have found a similar decrease in activity with deprivation (16) or no differences between groups (5, 8, 12, 13). However, the tendency to leave a familiar environment is greater in deprived than nondeprived rats (4, 15) and DeLorge and Bolles (6) found that deprived rats made more investigatory responses than nondeprived controls. The importance of a valid indicator of exploration is obviously of crucial importance in these experiments.

In the present experiment exploration was defined in terms of operations which have a greater face validity than locomotion. The tendencies to leave a dark area to sniff within a bright field and to jump through an opening to enter another field were two such operations. The present finding that deprived rats engaged in more exploration than nondeprived rats is in agreement with the data of DeLorge and Bolles (6) and indicates that locomotion alone is not a valid indicator of exploration.

The only age differences in exploration obtained in Experiment 1 were due to the lowered scores of deprived senescent rats on Trial 2 exploration during Day 5. Such findings are consistent with the general hypothesis that aged rats would show a decrement in exploration on Trial 2 and support Richter's hypothesis (11), based on activity-wheel measures, that senescent rats are more nocturnal (i.e., are not active in light) than young rats. The general lack of age differences is primarily a function of the specific test ages. In earlier work at this laboratory (unpublished) it was found that differences between adolescent (2-months-old), old mature (12-months-old) and senescent (24-months-old) male rats were not very great while a peak in exploratory behavior occurred at 1 and 3 months of age. Thus, the present results are not in conflict with those of Furchtgott, *et al* (7) which showed that sniffing behavior was a decreasing function with increasing age for rats approximately 1-, 6-, and 12-months old.

Experiment 2 was run when the subjects were 3-, 12-, and 24-months old to determine further changes in exploration as a function of age and depriva-

tion. The young nondeprived rats engaged in more exploration and less lying without sniffing or grooming than both older groups. These results supplement the preceding findings. In order to make comparisons between young and old groups, it is necessary to utilize animals within the range of 3 to 24 months of age or risk missing differences due to rapid behavioral changes over the range of 31 to 94 days. The behavior during this test is assumed to be independent of preceding tests because control runs of animals run cross-sectionally and longitudinally have yielded similar results at this age.

Because differences between deprived and nondeprived 3-months-old animals in exploring the bright area were nonsignificant, it is probable that when making such comparisons, care should be taken to specify whether this is a period during the life-span when novel stimulation would normally elicit vigorous exploration in nondeprived animals. In addition, it is necessary to determine what the relations are between behavioral response patterns other than those involving locomotion, such as sniffing, lying and grooming.

E. SUMMARY

Food-deprived and nondeprived male albino rats age 1.5 to 24 months were tested in a variety of open-field measures of exploration and activity. Locomotor activity of nondeprived rats within a simple field was a decreasing function of increasing age. Deprived young rats engaged in less locomotion than nondeprived young rats, while such responses were increased for deprived senescent rats in comparison with nondeprived controls. Deprivation resulted in an increase of behavior defined as exploration and an increase in activity within a complex field at all ages. Although no marked differences in exploration were found as a function of age for Ss 1.5-, 10-, and 22-months old, exploration was a decreasing function with increasing age at 3, 12, and 24 months. In general, behavioral differences as a function of age and deprivation are complex and for any comparison between isolated age groups, responses other than locomotion must be considered.

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SOME EFFECTS ON OPERANT CONDITIONING OF IONIZING RADIATION TO THE WHOLE-HEAD*¹

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A. PROBLEM

The present experiments are part of a series of studies on the effects of ionizing radiation on response rate during operant conditioning. Earlier studies have examined (a) response rate during daily whole-body exposure to x-irradiation (6), (b) behavioral changes during 20 continuous hours of whole-body x-irradiation (5), and (c) response rate for water reinforcement following whole-body gamma irradiation (8).

Arnold (1) and Blair and Arnold (4) have studied the effects of whole-head x-irradiation on maze acquisition and retention and found that, in general, irradiated rats were superior to controls with total dosages of 300r, 800r, 2000r, and 2500r of x-irradiation. Blair (3) and Arnold and Cho (2), using 500r cranial x-irradiation, found the irradiated animals were superior to sham-irradiated controls on maze learning.

The present studies were conducted to examine the effects of whole-head x-irradiation on appetitional and avoidance response rates in rats.

B. EXPERIMENT I

1. Subjects

In the first study 30 male albino rats of the Sprague-Dawley strain, approximately 120 days old at the beginning of the experiment, were used as subjects. They were housed with a maximum of six to a cage in air-conditioned quarters and were given water *ad libitum* in the home cages. In addition to pellets (0.040 gm. each) received as rewards during the experimental period, they were given three pellets of Purina Lab Chow after each daily run on the problem.

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2. *Apparatus and Procedures*

The subjects were trained daily, before radiation procedures were commenced, to respond on a 10-to-1 schedule of reinforcement in a Skinner Box until a level of approximately 27 responses per minute was attained. In addition to operant-conditioning training, the animals were placed in the type of restraint equipment to be used during irradiation for 26 minutes and 40 seconds for several days prior to exposure for habituation training to restraint during exposure. Before exposure the animals were divided into five matched groups based on performance records for the five days preceding exposure. The groups then were exposed to sham treatment, 1000r, 2000r, 4000r, and 8000r of x-irradiation to the whole-head, respectively.

The radiation source was a Picker self-rectifying half-wave 250 kvp 18 ma. therapeutic x-ray unit. The inherent filtration for the machine is 0.25 mm copper plus 2 mm aluminum. In the present study 1 mm aluminum and .25 mm copper were added. Radiation exposure was performed at the maximum setting 250 kvp 18 ma. and a target-to-object distance of 27.25 cm, which provided a dose rate for all groups of 300r/min. The exposure lead cylinder was five inches in diameter with a two-inch-diameter opening in the center to contain the animal's body during irradiation. The animal's exposed head was immobilized by a guillotine-type lock on the front end of the lead cylinder. After an animal had been inserted in the exposure cylinder, a lead plug was put in the rear end of the cylinder to prevent body irradiation resulting from scatter. Following exposure or sham-irradiation all animals were returned to their home cages for one hour, then were run ten minutes on the operant-conditioning equipment. After the exposure day, animals were run 10 minutes daily at approximately the same time for six days.

3. *Results and Discussion*

Data for analyses were available on 26 animals. In each of the two highest dose groups, one *S* received a reduced dose and one *S* died within the last two days of the postirradiation period.

For the preirradiation measures and the six test periods postirradiation, all effects were significant beyond the .001 probability level (see Table 1). Of particular interest is the Groups $\times$ Days interaction, the general nature of which can be seen in Figure 1. There appear to be two major sources of variation to account for in this interaction: (a) a general divergence of the group trends, which is a monotonic inverse function of dose, and (b) a performance drop, recovery, then a second drop in the irradiated groups, somewhat in relation to dose received.

For a more definitive test of the day-to-day trends and the differences between these trends, the Days and the Groups $\times$ Days variances were separated into independent components to determine the contributions of the linear tendency and those of the simple and consistent fluctuations (7). On the basis of the general divergence of the groups from day to day, it was expected that a large portion of the interaction variation would be accounted

TABLE 1
EXPERIMENT 1: SUMMARY OF ANALYSIS OF VARIANCE

Source	df	MS	F	p
Groups (G)	4	638.75	12.71	.001
Error (between)	21	128.97		
Total (between)	25			
Days (D)	6	176.18	8.84	.001
Linear	(1)	486.30	12.57	.005
Quadratic	(1)	190.49	8.91	.01
Cubic	(1)	315.92	37.04	.001
Quartic	(1)	49.68	2.45	NS
Quintic	(1)	9.89	<1.00	NS
Sextic	(1)	4.78	<1.00	NS
G $\times$ D	24	120.22	6.03	.001
Linear	(4)	374.74	9.69	.001
Quadratic	(4)	186.18	8.71	.001
Cubic	(4)	97.43	11.42	.001
Quartic	(4)	26.11	1.29	NS
Quintic	(4)	29.93	1.89	NS
Sextic	(4)	6.95	<1.00	NS
Error (within)	126	19.94		
Linear	(21)	38.67		
Quadratic	(21)	21.37		
Cubic	(21)	8.53		
Quartic	(21)	20.25		
Quintic	(21)	15.83		
Sextic	(21)	14.96		
Total (within)	156			
Total	181			

for by differences between linear trends. The tendency, most obvious in the 4000r and 8000r groups, for performance to drop abruptly just after irradiation, then to recover, then to drop again, should best be fitted by weighting coefficients of the second degree orthogonal polynomial, which extracts the cubic component of variance. In Table 1 it can be seen that the linear, cubic, and also the quadratic components were significant for both the general time effect and the interaction. The quadratic components represent tendencies and differences between tendencies for the trends to follow the shape of a parabola. However, the quadratic trends—and for that matter the linear trends—

although worth noting, are not of primary interest due to the existence of the higher order cubic trends.

The tendency in the irradiated groups, contrasted with the control group, for performance to drop, then recover, then to drop again, appears to be unique to these conditions of irradiation. In order to test adequately the

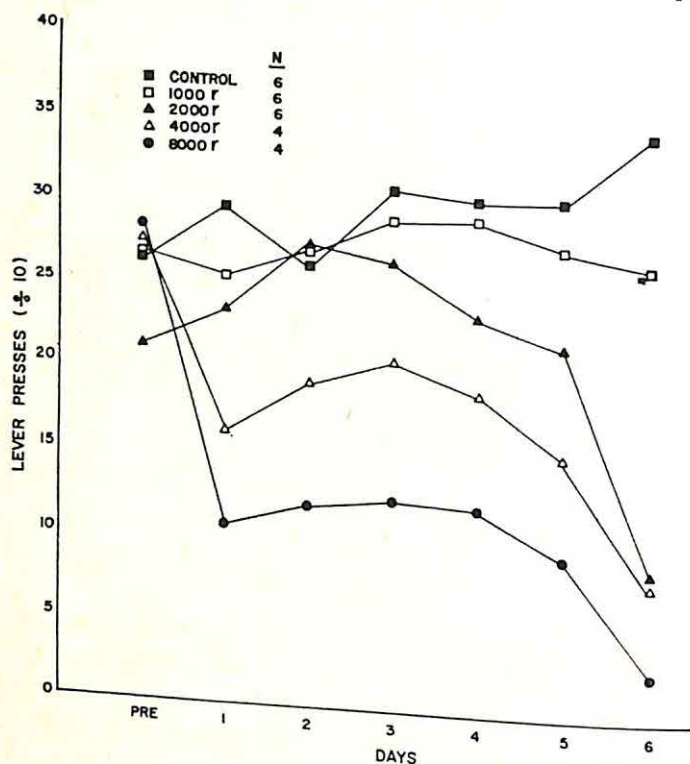


FIGURE 1
LEVER PRESSES FOR FOOD REWARD

validity of this effect several additional analyses were performed. First, it was established that the combined scores of the irradiated groups differed from the control group with respect to the down-up-down tendency. The cubic component for this comparison was found to contain 44 per cent of the total interaction variance with p less than .001. The remaining 56 per cent (between irradiated groups) was significant at p less than .005. Second, the recovery and drop tendency in the postirradiation measures was tested as the quadratic component of the joint and separate trends following irradiation. In this case the difference between all group trends, between control group

and combined-irradiate-group trends, and between the irradiate-group trends all were significant beyond the .001 level. Of the total variance for the quadratic component of interaction, 57 per cent was taken up by the difference between control and combined-irradiate-group trends. Third, performance changes one hour after irradiation were tested as the interaction between group means and the preirradiation *versus* the first postirradiation means. The overall interaction and that between irradiate groups were found to be significant beyond the .005 level; the control *versus* combined-irradiate-groups interaction was beyond the .025 level. Finally, tests were made for Day 1 *versus* Day 3 and Day 3 *versus* Day 6 postirradiation differences among the irradiate groups. For the first comparison the difference between days for all groups combined was significant beyond the .025 level; the interaction mean square was less than that for error. For the comparison between Days 3 and 6, both the difference between days and the interaction were significant beyond the .001 level.²

Considered together, analyses of the data obtained in this study indicate that there was a significant depression in lever-pressing performance among higher-level exposed groups one hour after irradiation, and that this depression was followed by a recovery period and then by a second, generally more severe, drop in performance. The effect appears to have been dose related.

C. EXPERIMENT 2

1. Subjects

Twenty-five male, albino rats of the Sprague-Dawley strain were used as subjects in the study of avoidance behavior following whole-head x-irradiation. The Ss, approximately 120 days old at the beginning of the experiment, were housed five to a cage in air-conditioned quarters and were given water and Purina Lab Chow *ad libitum*.

2. Apparatus and Procedures

The Ss were trained in a 10-unit operant-conditioning apparatus to press a lever in order to avoid or escape shock delivered through a grid cage floor.

The test cages were modified Gerbrands Model C cages, 10-1/2" L X

² The purpose of the last two sets of analyses may not be readily apparent as they overlap the trend analyses. However, the existence of a significant quadratic or higher order component does not, of itself, insure that there exists a significant change in one direction followed by one or more significant reversals. Interpretation of the fitted polynomial functions in this study rests upon consideration of probable factors determining the trends and the closeness of fit of the functions to the raw trends.

8-3/8" W $\times$ 10-1/4" H. These boxes have transparent-plexiglass sides and tops, aluminum ends, and floors constructed of 3/32" stainless-steel rods 1/2" apart on centers. The rods were connected through a control unit alternately to the positive and negative poles of a power supply which delivered pulsed, D.C. current limited to 1.0 ma. across 10,000 ohms. A six-watt incandescent lamp was mounted 1-1/2" from one side of a cage and 4" above the grid floor. The bar which the *S* pressed to avoid or escape shock protruded upward through the grid floor 3" from the end of the cage opposite the cue light.

TABLE 2
EXPERIMENT 2: SUMMARY OF ANALYSIS OF VARIANCE

Source	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Groups (G)	4	4000.95		
Error (between)	20	1459.18	2.74	
Total (between)	24			
Days (D)	5	994.60		
Linear	(1)	2798.50	11.08	
Quadratic	(1)	1060.03	21.29	
Cubic	(1)	253.00	7.36	
G $\times$ D			5.60	
Linear	20	375.44	18.77	
Quadratic	(4)	1330.35	10.12	
Cubic	(4)	335.46	2.33	
Error (within)	100	103.30	2.29	
Linear	(20)	89.70		
Quadratic	(20)	131.42		
Cubic	(20)	143.99		
Total (within)	125	45.17		
Total	149			

The bar was 3/16" aluminum welding rod, approximately 6" long, and extended across the cage parallel to and approximately 1" above the floor.

A trial consisted of a five-second interval (S-1) during which the shock was off and both the six-watt light and a 1000 cps tone at 80 dB, SPL, were on. This interval was followed by a one-second period (S-2) during which the shock was on and the light and tone were off. An *S* could avoid the shock by pressing the bar during the S-1 period, or escape shock by pressing the bar during the S-2 period. If an *S* held the bar down, he missed shock during the first cycle but received it on each subsequent cycle as long as the bar was depressed. For each box separate counters recorded the number of shocks avoided and the number of bar presses.

Preexposure training consisted of 3,000 trials at a rate of 200 trials per day at which point performance was asymptotic at a mean level of 52 per cent

shock avoidances. The Ss then were divided into five matched groups on the basis of mean performance during the previous five days and the groups, respectively, were subjected to sham, 1000r, 2000r, 4000r, and 8000r whole-head x-irradiation. The x-ray equipment and the irradiation procedure used in this study were the same as in Experiment 1.

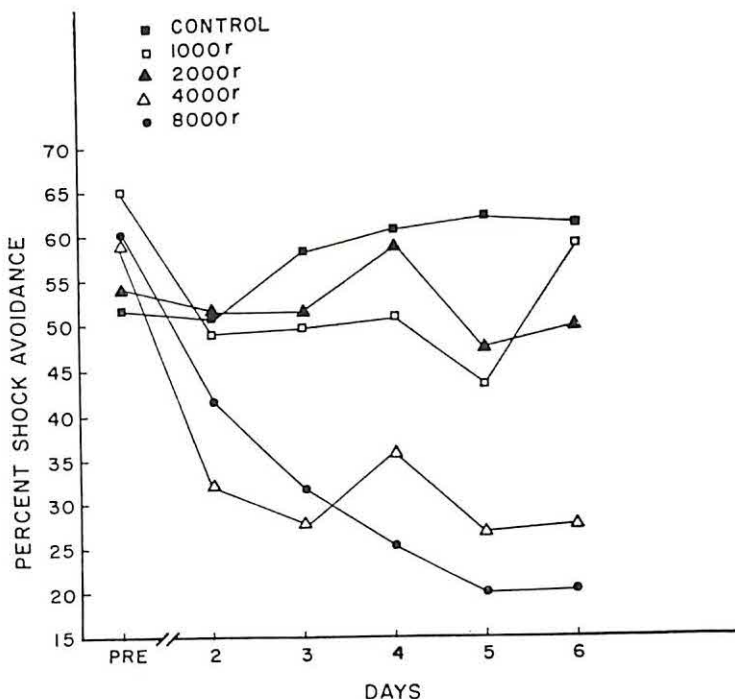


FIGURE 2
PER CENT LEVER PRESSES FOR SHOCK AVOIDANCE

Twenty-four hours after irradiation and each day following for a total of five days the Ss were given 200 trials on the avoidance task.

3. Results and Discussion

Analyses of the results for avoidance behavior are summarized in Table 2. As was the case in Experiment 1, it is the Groups $\times$ Days interaction that is of particular interest and, again, this effect was found to be significant beyond the .005 probability level. The nature of this interaction can be seen readily in Figure 2. It is due generally to a dose-related fanning out of the group performance curves across the six test days with the higher dose groups tending to show progressively fewer avoidance responses. This gross aspect of the

trend differences constitutes the linear component of the interaction, an effect which was significant beyond .005 level and accounted for slightly less than 71 per cent of the overall Groups $\times$ Days interaction variance. Neither of the next two higher-order components of the interaction reached an acceptable level of significance—as they did in the first study—nor is there much evidence of such effects in Figure 2. Although no measures were available immediately after irradiation in the present study, the trends thereafter differ obviously from those of Experiment 1 in two respects: (a) The 8000r group shows no recovery, and (b) such evidence as there is for temporary recovery in the other irradiated groups is not evident until Day 4. It may also be of interest to note that the primary gap in the Experiment 2 performance data is between 2000 and 4000r whereas in the appetitive study the main gap was between 1000 and 2000r.

D. SUMMARY AND CONCLUSION

Experiment 1: Twenty-six rats were trained in a Skinner box to work for lab pellets. At asymptote they were divided into matched groups, then exposed to sham treatment or 1000r, 2000r, 4000r, or 8000r of x-irradiation at 300r/minute. One hour after exposure the performance of irradiated Ss was depressed in general relation to dose received. This was followed by a two-day recovery after which terminal depression occurred.

Experiment 2: Twenty-five rats were trained to avoid shock in a modified Skinner box, then were divided equally into five matched groups. Radiation doses and rate were the same as in Experiment 1. The Ss' ability to avoid shocks declined as a function of the magnitude of dose.

Considering both experiments together, head exposure at these dosages produced a marked depression in performance that appears to be dose related. The effect is seen one hour after exposure, which suggests a CNS effect rather than a gastrointestinal one. The apparent discrepancy between these experiments and the work of Arnold and co-workers may be due to differences in radiation parameters or to specificity of the effects to the types of tests used in the different experiments.

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THE MOST CREATIVE YEARS OF ENGINEERS AND OTHER TECHNOLOGISTS*

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A. INTRODUCTION

What are the most creative years of engineers and other technologists? Everybody, or almost everybody, knows that man has a strong impulse to argue from his own personal observation. But for answering the question raised here one's personal observation is likely to be woefully inadequate. This article presents a plain unadorned account of what has occurred under the conditions that have prevailed up to now. Conjecture as to what might possibly have happened under other and purely hypothetical conditions is left to those who prefer conjecture to solid fact. The following highly quotable and laudable statement about the year *AD* 1248 by Frederick the Second (Holy Roman emperor) is apropos: "Our purpose is to set forth the things that are, as they are." In preparing this manuscript I have made every humanly possible effort to follow this guideline.

B. PROCEDURE

Table 1 and the solid line of Figure 1 present, by five-year intervals, the chronological ages at which 119 contributors, now deceased and born subsequent to the year *AD* 1774, made 273 notable contributions to our knowledge of electrical engineering. Age data for contributors born prior to 1775 were not employed for drawing this curve because, as has been shown elsewhere (13), there are good reasons for suspecting that age data for contributors born so long ago are none too trustworthy.

The information employed for constructing the solid line of Figure 1 was obtained from Dunsheath's *A History of Electrical Engineering* (5). That is to say, the contributions used for constructing this solid line were originally selected, not by me, but by a well-known historian of electrical engineering who published what he intended to be a factual record, with no thought of obtaining evidence for or against the relative success of any particular age

* Received in the Editorial Office on October 15, 1965. Copyright, 1966, by The Journal Press.

† The Journal Press regrets to report that Dr. Lehman died in August 1965.

TABLE 1
AVERAGE NUMBER OF CONTRIBUTIONS *per* FIVE-YEAR INTERVAL*

Data used in:	Age interval														
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Fig. 1 (solid line)	.007	.025	.068	<i>.113</i>	.072	.075	.053	.024	.018	.019	.012	.003			
Fig. 1 (broken line)	—	.019	.031	.063	<i>.068</i>	.033	.048	.037	.013	.019	.006	.007			
Fig. 2 (solid line)	.009	.014	.045	<i>.060</i>	.046	.046	.027	.032	.006	.008	.010	.005	.003		
Fig. 2 (broken line)	.001	.007	.029	.058	<i>.062</i>	.046	.033	.018	.016	.013	.004	.001	.001		
Fig. 3 (solid line)	.003	.016	.049	.050	<i>.058</i>	.049	.029	.022	.020	.011	.008	.005	.007	.004	
Fig. 3 (broken line)	.002	.016	.032	.046	<i>.050</i>	.037	.038	.034	.020	.002	.003				
Fig. 4 (solid line)	.002	.014	.053	<i>.064</i>	.049	.036	.035	.025	.017	.004	.001	.002			
Fig. 4 (broken line)	—	.020	.047	<i>.051</i>	.039	.043	.027	.025	.013	.010	.005				
Fig. 5 (solid line)	.002	.004	.033	.037	<i>.052</i>	.034	.033	.019	.009	.010	.004	.004			
Fig. 5 (broken line)	.003	.013	.035	.038	<i>.063</i>	.047	.033	.028	.015	.009	—	.006			
Fig. 6 (solid line)	.001	.015	.039	.070	<i>.095</i>	.085	.064	.044	.030	.016	.020	.004	.010		
Fig. 6 (broken line)	.002	.013	.040	.071	<i>.077</i>	.071	.043	.038	.033	.003	.004	.005			
Fig. 7 (solid line)	—	.016	.030	.112	<i>.114</i>	.076	.077	.050	.039	.021	.012				
Fig. 7 (broken line)	.002	.023	.055	<i>.079</i>	.070	.041	.027	.024	.012	.007	.008				
Fig. 8 (solid line)	.005	.020	.057	.090	<i>.110</i>	.089	.068	.061	.047	.050	.027	.023	.022	.013	.048
Fig. 8 (broken line)	—	.010	.066	.078	<i>.082</i>	.070	.056	.037	.034	.029	.030	.022			

* The peak of each statistical distribution is in italics.

group. If the contributions employed for making this curve had been chosen by someone who was trying to confirm an *a priori* conclusion, rather than merely to record the historical facts, the present study obviously would have no value.

In study of the solid line of Figure 1, it should be understood that for each age group it sets forth the rate of output: i.e., the *average* number of contri-

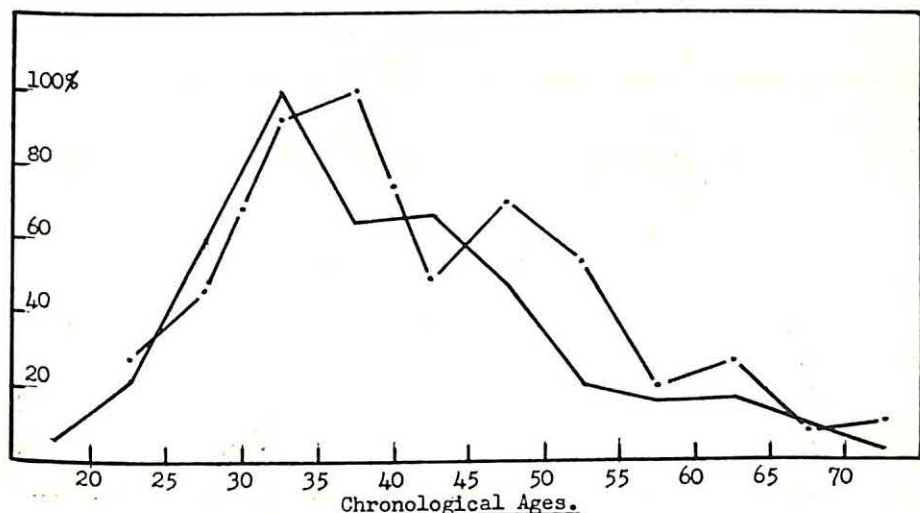


FIGURE 1

AGE DIFFERENCES IN RATE OF PRODUCTION OF CONTRIBUTIONS TO ELECTRICAL
ENGINEERING AND MECHANICAL ENGINEERING

Solid line: Production rate of 273 contributions to electrical engineering by 119 contributors (born after 1774) according to age.

Broken line: Production rate of 104 contributions to mechanical engineering by 66 contributors.

Age of maximum production rate taken as 100 per cent. Production at other ages plotted as percentage of the maximum.

butions made during each five-year interval. This procedure corrects automatically for the fact that younger contributors are always likely to be more numerous than older ones, and hence that different numbers of people are left alive in each successively older age group.

For example, for the contributions set forth by the solid line of Figure 1, it was found that the *maximum* average rate of output was 0.113 of a contribution *per person per annum* during ages 30 to 34 inclusive. The high level of excellence of these contributions can best be appreciated when it is realized that this production rate amounts to approximately one contribution for each nine years of work by the best men in the field—as judged by an eminent historian

of electrical engineering. Similar rates of output were computed for each five-year interval from age 15 and up.

Thus, for the contributors who were still among the living at ages 50-54 inclusive, the annual production rate had fallen to only 0.0238 of a contribution *per person per annum*. To facilitate making direct comparisons of the production rates of the successive age groups, the obtained fractional rates of output were all converted to percentages by taking the maximum production rate as 100 per cent and finding the proportionate percentage values for each

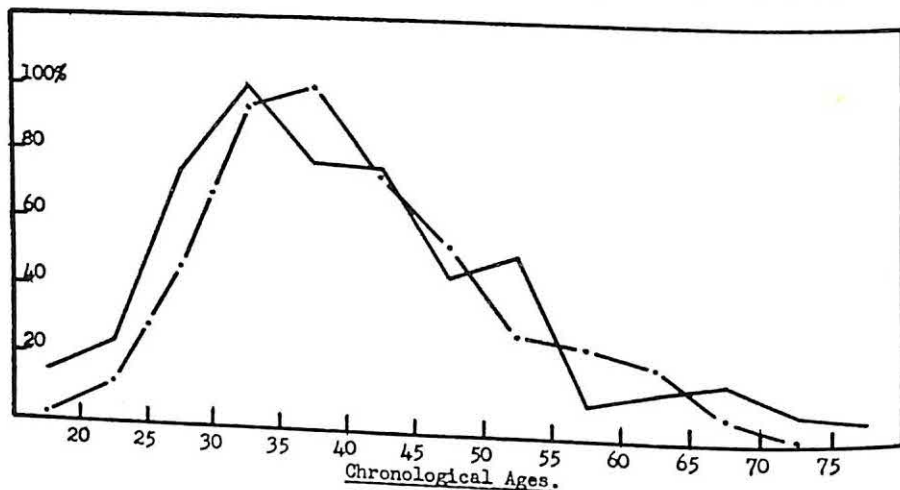


FIGURE 2
AGE DIFFERENCES IN RATE OF PRODUCTION OF CONTRIBUTIONS TO ENGINEERING
IN GENERAL AND TO SOCIAL ENGINEERING
Solid line: 228 contributions by 155 contributors to social engineering.
Broken line: 226 contributions by 168 contributors to engineering in general.

of the other age groups. When this was done the highest production rate (0.113), which occurred at age 30-34, became 100 per cent; and the decimal fraction (0.0238), which represents the annual rate of output for age group 50-54, became 30 per cent ($0.0238/0.113$).

As would have been expected, the annual rate of output at ages 15-19 was far below the maximum. It amounts to only 0.00163 of a contribution *per person per annum*, or about 3 per cent of the topmost rate. Notice how the production rate dwindles for each age group beyond 30-34. It falls to 0.0527 (47 per cent) at ages 45-49, and to nearly zero beyond age 70. This latter finding is by no means offered as evidence or even a suggestion that the contributors became less *capable* of producing after they had passed age 34. As was stated earlier, this study tells merely what has occurred under the con-

ditions that have existed heretofore. Under other circumstances each and every age group might have done much better—for aught I know.

The broken line of Figure 1 was drawn in the same way as was its mate except that this broken line is based upon information obtained from a different source: namely, from Cressy's *A Hundred Years of Mechanical Engineering* (2). Notice that, although the peaks of the two curves of Figure 1 do not occur at exactly the same age interval, both of them occur during the thirties.

Remarks thus far made should enable the reader to understand the remaining graphs by merely reading their legends. Figure 2 is based on two histories (1, 6), each of which has to do with engineering in general. The next five curves (Figures 3 and 4, and the solid line of Figure 5), set forth information (4, 7, 10, 17, 18) regarding technology as a whole. By way of contrast the broken line of Figure 5 pertains to a more specific area: namely, metallurgy (3). Today, when structural steel and reinforced concrete are so widely used in bridge construction, the following testimony with reference to an earlier prevalent attitude seems all but unbelievable even though we know it is true.

It is now difficult for us to realize the initial resistance to the adoption of steel for bridges and the courage that was required to choose that material in its early days. As late as 1877 in England, Board of Trade regulations actually prohibited the use of steel in bridge construction. . . .

The parallel situation, a generation later, with respect to the introduction of reinforced concrete, was effectively expressed by Professor William H. Burr in the Proceedings of the *American Society of Civil Engineers* in 1908. . . .

"Experience, of course, has more than justified the advocates of structural steel, and that metal has now proved to be, not only reliable, but by far the very best structural material ever yet made available for a wide range of purposes. . . . Reinforced concrete is now passing through a similar phase. . . ." (19, p. 270).

Figure 6 reveals the production rates for contributors (now deceased) as found in two histories of photography (8, 16). That photography (in large part a product of technology), in addition to being an art, is also a highly useful scientific tool, is documented by the following observation.

But for the photographic recording of spectra, many branches of science must have come to a standstill. . . . These photographic developments have many side-issues, e.g., infra-red plates for registering through mist and fog scenes hundreds of miles away . . . the detection of radioactivity by photographic means dates from 1896; indeed Becquerel's original observation was through the accidental fogging of a photographic plate. There is now an enormous usage of photographic plates and films

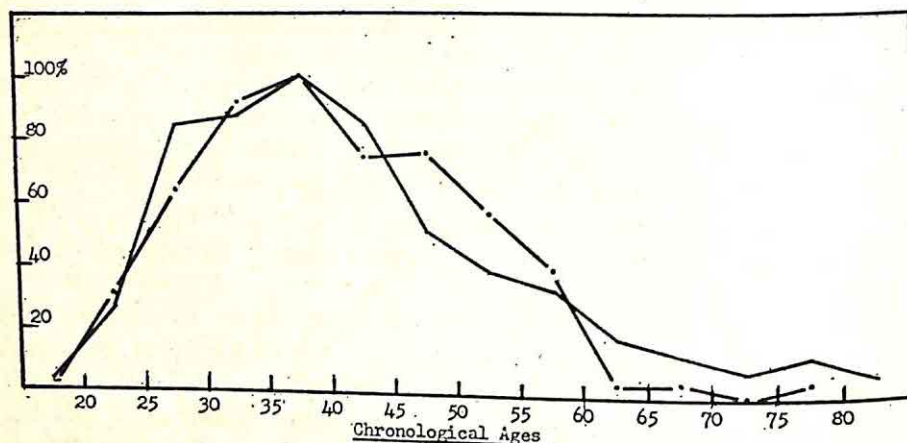


FIGURE 3
AGE DIFFERENCES IN RATE OF PRODUCTION OF CONTRIBUTIONS TO TECHNOLOGY
Solid line: 722 contributions by 478 contributors.
Broken line: 163 contributions by 121 contributors.

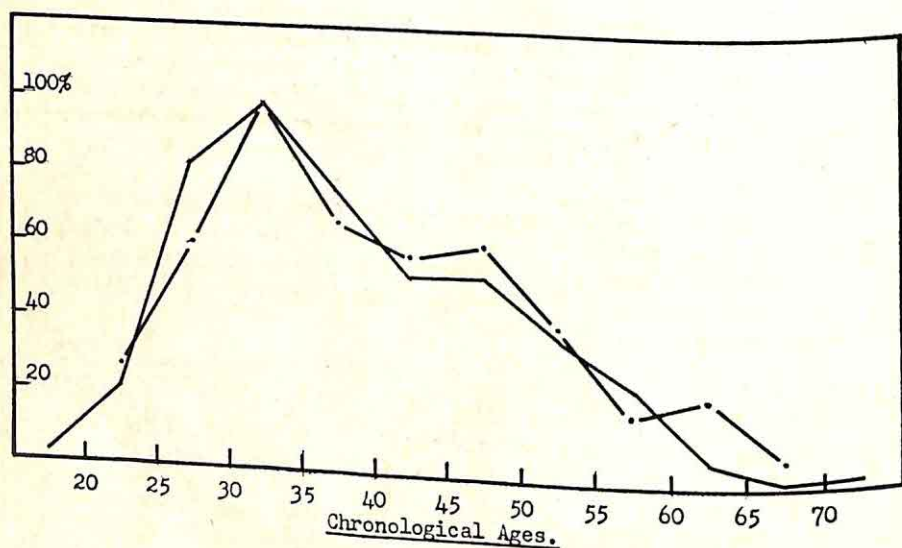


FIGURE 4
AGE DIFFERENCES IN RATE OF PRODUCTION OF CONTRIBUTIONS TO SCIENCE AND TECHNOLOGY, AND TO AMERICAN TECHNOLOGY
Solid line: 355 contributions to science and technology by 245 contributors.
Broken line: 168 contributions to American technology by 127 contributors.

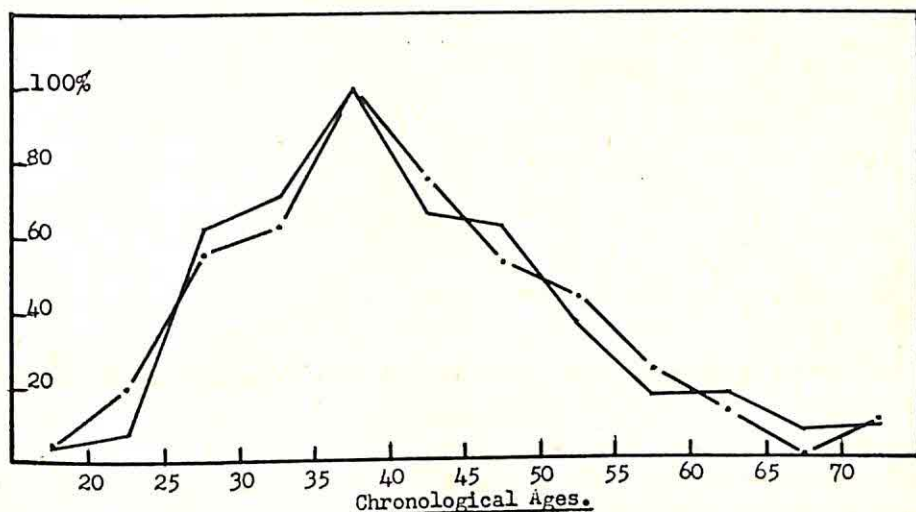


FIGURE 5

AGE DIFFERENCES IN RATE OF PRODUCTION OF CONTRIBUTIONS TO TECHNOLOGY
AND TO METALLURGY

Solid line: 109 contributions to technology by 97 contributors.

Broken line: 87 contributions to metallurgy by 63 contributors.

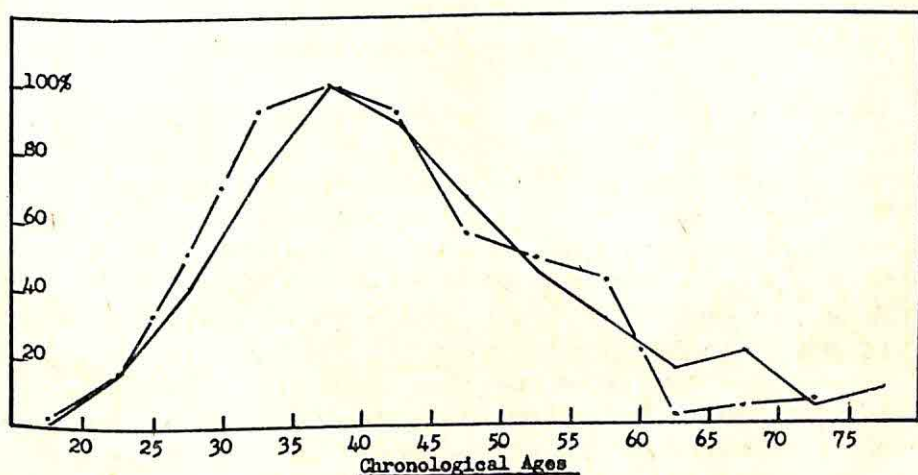


FIGURE 6

AGE DIFFERENCES IN RATE OF PRODUCTION OF CONTRIBUTIONS TO PHOTOGRAPHY

Solid line: 434 contributions by 190 contributors.

Broken line: 167 contributions by 87 contributors.

for revealing, by X-rays, foreign objects or disturbances in the human body, or flaws in metal castings or manufactured articles. Most scientific of all was the photographic registrations which revealed the wave-properties of electrons.

Rutherford had to look at hundreds of thousands of particle tracks on the photographic plates taken of Wilson cloud-chamber images before he found the one which showed the transformation of an atom of nitrogen into an atom of oxygen, the first deliberate transmutation of matter, leading to the postulation of the neutron, its discovery by Chadwick in the early '30s, and its use in atom bombs in the '40s. What speed of thought, verification, and consolidation! Without suitable photographic plates, would Rutherford or his students ever have got so far? (4, p. 305).

One thinks in this connection of the recently telecast pictures of the surface of the moon, a feat dependent in large part upon engineering and technology and which, except for photography, would have been altogether impossible; hence, the impracticality of trying to draw a sharp line of demarcation between some of the work of the creative technologist and some of the work of the creative scientist.

Radio has been developed so recently that many important contributions thereto have been made by contributors who are still among the living. Therefore, the solid line of Figure 7 sets forth age data only for still-living contributors to the radio industry (15). This solid line was so drawn as to make adequate allowance for the fact that those contributors, or many of them, are still alive and continuing to make their contributions. Here is how it was done.

Although the Maclaurin-Harman history, which provided the information used for constructing the solid line of Figure 7, was published in 1949, it includes no contribution made subsequent to 1941. Therefore, in order to obtain valid arithmetical averages, it was assumed that each of the then-living contributors died in 1941. That is to say, regardless of when it was published, insofar as this present study has to do with contributors who are still among the living, any book that includes no contribution made subsequent to, let us say, year X, has a terminal year of X.

Employment of the year of publication of the Maclaurin-Harman book (1949), rather than its terminal date (1941), would have been unsound for my present purpose because such a procedure would have counted as unfruitful eight full years during which production by the still-living contributors may have occurred but which could not have received due recognition in the Maclaurin-Harman history.

It is of course true that since many and perhaps most of the contributors

whose rate of production is shown by the solid line of Figure 7 are still living and producing, this curve does not take into account their entire lifework. But it is true also that others who were too young to have started making their contributions prior to 1941 are now contributing. Hence, it is not necessarily true that the *relative* production rates of the successive still-living age groups, as revealed by the solid line of Figure 7 will change very greatly.

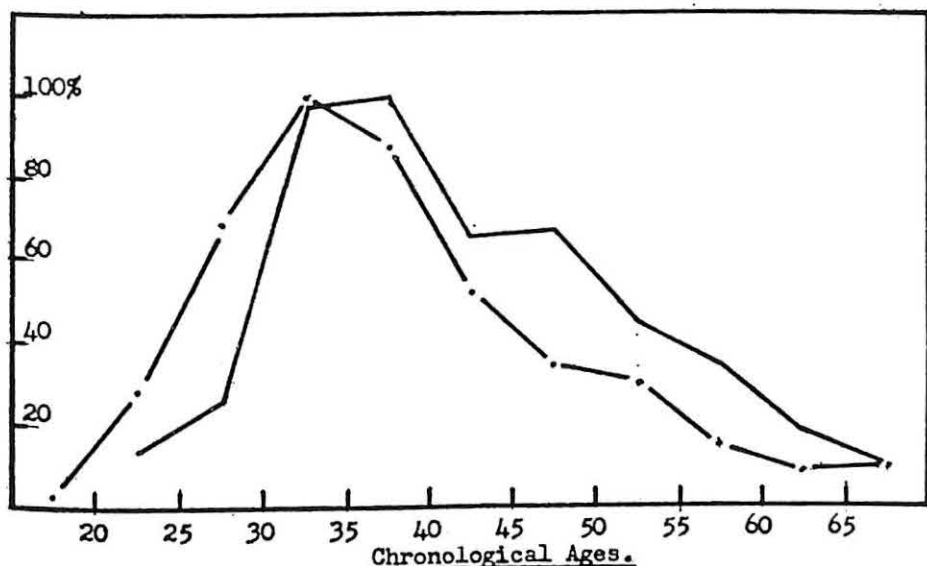


FIGURE 7
AGE DIFFERENCES IN RATE OF PRODUCTION OF CONTRIBUTIONS BY CONTRIBUTORS
WHO ARE STILL AMONG THE LIVING

Solid line: 197 contributions to the radio industry by 85 contributors.

Broken line: 268 contributions to engineering, to technology, and to metallurgy.
(See text.)

Cross-comparisons of the several age curves (for the still-living and for the deceased age groups) appearing in the present study suggest the opposite conclusion. If the possible cross-comparisons within the confines of the present study are too few in number to be convincing evidence, a goodly number of additional curves are available for the purpose of making such an analysis (12, 14).

Figures 1 to 6 inclusive presented no information at all regarding the production rates of contributors who are still among the living. This was because each of the 12 source books that provided information for constructing them contained too few contributions by still-living contributors to permit the

construction of six separate age curves for the still-living contributors. In order to surmount that roadblock, and at the same time to utilize profitably as much of my assembled data as was possible, the broken line of Figure 7 was drawn by combining all of the age data for still-living contributors as found in the 12 aforementioned histories: i.e., considering the 12 of them as one book.

The solid line of Figure 8 sets forth information regarding 147 contributors (now deceased) who made 443 contributions to our present-day understanding

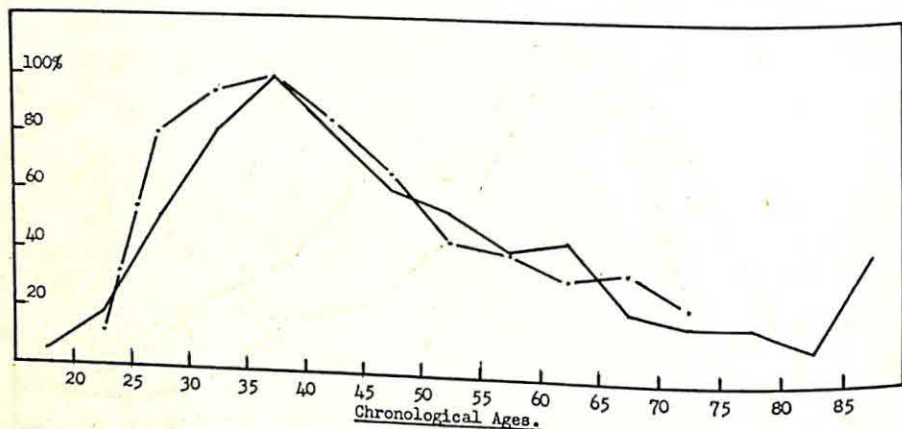


FIGURE 8
AGE DIFFERENCES IN RATE OF PRODUCTION OF CONTRIBUTIONS TO OUR
UNDERSTANDING OF STRENGTH OF MATERIALS
Solid line: 443 contributions by 147 contributors (now deceased).
Broken line: 250 contributions by 121 contributors who were still among the living
in 1952.

of "strength of materials" (21). The broken line of this figure reflects, on the other hand, the production rate of 121 contributors who are still among the living.

C. DISCUSSION

In this study it is not assumed that when a contribution to any given field is first announced, any one individual can say precisely just how important it is destined to be; nor is the claim made that any one historian is able to identify each and every outstanding contribution to his field. It is assumed only that the author of a standard history can assemble a group of contributions that collectively possess high merit, and that the historian is likely to do this with no personal bias toward any one or more age groups.

It also seems a reasonable conjecture that the still-living contributors whose

published findings are now being cited in our specialized histories are the most likely present-day candidates for professional immortality in their respective fields. Objection may be raised to publication of production rates for still-living individuals on the ground that the future may prove the sterling value of some recently published works that are now being entirely ignored and, conversely, that favorable contemporary evaluations of present-day contributions in no way insures that they will be highly prized by future generations.

Although re-evaluations will certainly occur, it nevertheless is individual contributions, and not the collective output of five-year age groups, that are chosen for inclusion in our standard histories of specific disciplines. That is to say, it is probable that such changes in evaluation as may take place in the days to come will occur on a purely random basis *insofar as the ages of the contributors at time of making their contributions is concerned*. It therefore seems a reasonable assumption that at least a rough proportionality will be maintained between the way in which our ablest present-day historians evaluate the output of the successive still-living age groups and the way in which future historians will evaluate that output.

It is sometimes said that pure science must precede applied science, but this is only a half-truth. It would be much more accurate to say that applied science both springs from and supports pure science. Any who doubt the validity of this assertion are invited to read in Singer's *A History of Technology* (18) chapters 21 and 22 of Vol. 3, whose titles are respectively, "Precision instruments to 1500," and "The manufacture of scientific instruments from c1500 to c1700." If any still continue to be doubting Thomases they should then read the index of almost any modern catalogue of laboratory apparatus and supplies as well as three able discussions (11, 20, 22) which illustrate clearly the close interrelationship that exists between pure science and technological advances.

What produces the age decrements as found in each of the foregoing curves? To this query many writers offer many answers, all of which leave much that is not explained. These early decrements cannot be due to the early deaths of the geniuses. The statement "Whom the gods love die young" may apply to some few individuals but the vast majority of our great creative thinkers have not died young. Indeed, on the average the creative individual lives as long or even longer than do lesser mortals. Notice in column 8 of Table 2 (mean ages at time of death) that the median value of the mean ages at time of death is 71.81 years. And column 7 of this table (median ages at time of death) reveals that the median value of the median ages at time of death is

TABLE 2
SUMMARY OF FINDINGS WITH REFERENCE TO CHRONOLOGICAL AGE VERSUS THE MOST
CREATIVE YEARS OF ENGINEERS AND OTHER TECHNOLOGISTS

Data used in:	No. of contrib- utors (1)	No. of contribu- tions (2)	Ave. con- tributions per man (3)	Median age at time of achieving (4)	Mean age at time of achieving (5)
Fig. 1 Solid line	273	119	2.29	36.31	38.18
Fig. 1 Broken line	104	66	1.58	38.38	40.26
Fig. 2 Solid line	228	155	1.47	37.11	38.75
Fig. 2 Broken line	226	168	1.35	38.50	40.01
Fig. 3 Solid line	722	478	1.51	37.99	40.15
Fig. 3 Broken line	163	121	1.35	38.92	39.94
Fig. 4 Solid line	354	245	1.44	36.27	38.09
Fig. 4 Broken line	168	127	1.32	37.08	39.13
Fig. 5 Solid line	109	97	1.12	38.50	39.96
Fig. 5 Broken line	87	63	1.38	35.80	39.89
Fig. 6 Solid line	434	190	2.28	40.18	42.23
Fig. 6 Broken line	167	87	1.92	39.25	41.52
Fig. 7 Solid line	198	86	2.30	38.09	42.15
Fig. 7 Broken line	268	172	1.56	34.85	35.39
Fig. 8 Solid line	443	147	3.01	41.27	43.71
Fig. 8 Broken line	250	121	2.07	38.33	40.12
Median values				38.44	39.98

TABLE 2 (continued)

Data used in:	SD of distribu- tions (6)	Median age at death (7)	Mean age at death (8)	SD of distribu- tion (9)	Ages of maximum produc- tivity (10)
Fig. 1 Solid line	10.46	73.17	70.15	14.58	30-34
Fig. 1 Broken line	10.74	68.75	67.58	13.33	35-39
Fig. 2 Solid line	11.59	72.68	71.14	14.14	30-34
Fig. 2 Broken line	9.97	72.80	71.92	12.91	35-39
Fig. 3 Solid line	11.79	72.41	71.10	13.19	35-39
Fig. 3 Broken line	10.55	70.50	70.07	13.19	35-39
Fig. 4 Solid line	10.05	71.78	70.44	13.52	30-34
Fig. 4 Broken line	10.95	71.81	70.30	13.66	30-34
Fig. 5 Solid line	10.25	70.83	68.99	13.68	35-39
Fig. 5 Broken line	10.32	71.50	70.16	12.50	35-39
Fig. 6 Solid line	10.86	71.92	70.21	12.83	35-39
Fig. 6 Broken line	9.91	71.76	70.23	13.10	35-39
Fig. 7 Solid line	9.37				35-39
Fig. 7 Broken line	9.38				35-39
Fig. 8 Solid line	10.55				35-39
Fig. 8 Broken line	10.92				30-34
Median values		73.66	70.46	13.84	35-39
		70.23	71.81		35-39

70.23. These results are similar, moreover, to those obtained for creative workers in many other fields of endeavor (18).

It will be noted in column 4 of Table 2 that about *half* of the total number of contributions cited herein were made beyond age 38.44. This should be an encouragement to older individuals. No doubt it results in part from the fact that collectively, the contributors here studied had more potentially fruitful years subsequent to age 38.44 than they had prior thereto.

Inasmuch as a group trend has never applied to each individual within the group, the production rate as found for a group of contributors and individual production rate are two entirely different things. Both the gradual descents of the curves and the data of Table 1 reveal that, as regards the ages at time of achievement, there are many, many individual exceptions to the general group trend, and that an individual may do highly important creative work at any time from his late teens into his eighties.

These collective findings are a reminder of what the renowned psychologist, William James, once said. James, who served two terms as president of the American Psychological Association and one term as president of the American Philosophical Association, in his presidential address to the latter in 1906, asserted that men the world over possess unused abilities and that they rarely accomplish as much as their potential ability would warrant. Here are his exact words:

. . . as a rule men habitually use only a small part of the powers which they actually possess and which they might use under appropriate conditions. . . . Compared with what we ought to be, we are only half awake. Our fires are damped, our drafts are checked. We are making use of only a small part of our possible mental and physical resources (9, p. 237).

Today all professional psychologists agree with this statement. Since most *individuals* fail to attain their potential peak performance, no entire age group has ever done so. William James asserted also that *no nation* lives up to its full potential. Think for one moment of what has been occurring in the United States of America since the start of the post Sputnik era. This one example should suffice to document James's assertion with reference to the achievement of an entire nation.

D. SUMMARY

As I review what I have written here, I think of five facts that merit especial emphasis:

1. This study does not concern itself with productive work that was merely "publishable," but rather with output of far more than average merit.

2. No attempt was made to ascertain the *overall importance* or the *total value* of what the several age groups accomplished, but only to ascertain such of their creative output as was found in specialized histories.

3. As has been shown elsewhere (12, 14), the age decrements revealed herein apply not only to engineers and technologists but also to creative workers (both past and contemporary) in a goodly number of other fields.

4. It is well-nigh impossible to distinguish unequivocally between all technologists, engineers, and scientists relative to some of their creative processes and creative productions.

5. Whether the age decrements here described will persist in the years to come is something to which I don't pretend to have a trustworthy answer. Time alone will tell.

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VERBAL CONDITIONING OF COMMON-WORD AND UNCOMMON-WORD ASSOCIATIONS IN RETARDATE AND NORMALS*¹

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A. INTRODUCTION

The operant verbal-conditioning literature contains relatively few systematic studies of the effects of verbal reinforcement on the acquisition of verbal-response classes in retardate populations. Barnett, Pryer, and Ellis (2)—employing Taffel's technique with a retardate population—found that an experimental group given verbal reinforcement (“good”) for selecting particular pronouns showed a significant increase in their selections of the reinforced pronouns as compared with that of a control group receiving no reinforcement. Spradlin (10) reports the results of a study by Ezell, who investigated methods of increasing the fluency and complexity of the verbal behavior of severely retarded institutionalized children. Ezell found no significant differences between a group receiving “praise” and a control group not receiving “praise.” Horowitz (3) studied the relative effectiveness of different reinforcers and reinforcement schedules for the selection, by retardate children, of one of three picture stimuli. Horowitz used five reinforcing stimuli (candy, praise, smiling, candy and praise, and praise and smiling) under conditions of 50 per cent and 100 per cent reinforcement. She found candy and praise to be the most effective reinforcement, but the results for the two reinforcement schedules were equivocal. Miller and Griffith (5), studying conceptual behavior in retardate Ss, found that the differential social reinforcement of relevant and irrelevant associates to picture stimuli had no effect in facilitating subsequent abstraction performance requiring the use of the associates.

In the present study, the effects of verbal reinforcement on the acquisition of common-word associations and uncommon-word associations in two populations of retardates are investigated. Two previous studies, directly concerned with reinforcing this same class of verbal behavior, have been reported. Sommer, Witney, and Osmond (9) found that each of two groups of alcoholics

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rewarded with cigarettes for giving common-word and uncommon-word associations, respectively, showed significant increases in the use of both classes of reinforced responses. In the same study, a group of schizophrenic patients rewarded with cigarettes and praise showed a significant increase in the number of common responses. On a free-association transfer task, alcoholic *Ss* showed significant transfer effects; whereas schizophrenic *Ss* did not. Maltzman, Simon, and Licht (4) presented two groups of college *Ss* with stimulus words drawn from the Minnesota norms (7) and verbally reinforced (with "good") common-word or uncommon-word associations. Members of a control group received no verbal reinforcement. Maltzman, Simon, and Licht found that, in the group given reinforcement on the common-word associations, those *Ss* who could verbalize the reinforcement contingency gave significantly more common responses on the final block of 20 trials than did the group receiving no reinforcement. The other groups did not differ significantly from one another. No differences were found between the groups on the unusual-uses transfer task.

In the present experiment, the authors used the same stimulus materials for two reasons. We wished (a) to make direct comparisons with the results of the former studies and (b) to assess the extent to which retardate *Ss*, under conditions of verbal reinforcement, can learn both the typical and the atypical associative responses characteristic of a so-called "normal" population.

B. METHOD

1. Subjects

Ss with known organic brain damage and histories of epilepsy were excluded. Initially, the retardate population consisted of 84 institutionalized patients drawn from the Dixon State School²; however, 24 *Ss* were discarded because they failed to follow instructions during the practice sessions; consequently, the final retardate population consisted of 60 *Ss* (32 males and 28 females). All *Ss* had been tested with the 1937 revision of the Stanford-Binet (Form L) and were divided into two groups according to *MA* level: a Low-*MA* Group and a High-*MA* Group. Within each *MA* group, *Ss* were matched as closely as possible on age, sex, and length of institutionalization; and were randomly assigned to the respective treatment conditions.

Fifty-one children (23 males and 28 females) drawn from the second, third, and fourth grades of a local school system comprised the normal population.³

² We are indebted to Mr. David Edelson, superintendent of Dixon State School, for making these *Ss* available. In particular, we wish to thank Dr. Rolland Metzger and the Psychology Department for their assistance in varying stages of this study.

³ We wish to express our appreciation to Mr. Carl Cohoon, superintendent of the Malta School System, for making these children available.

Kuhlmann-Anderson intelligence scores were available for these normal *Ss*. *Ss* were matched as closely as possible according to *MA*, age, and sex; but were randomly assigned to treatment conditions.

Table 1 summarizes the *MA*s, *CA*s, and *IQ* scores for the retardate and the nonretardate populations and shows length-of-institutionalization data for the retardates.

2. Stimulus Materials

Stimulus materials were selected from the Minnesota norms (7). Sixty-five forced-choice items were constructed. Each item consisted of a stimulus word and two response words. For each item, one response word was a common-word association; the other response word was an uncommon-word association for the particular stimulus word of the item.

In most instances, common responses were defined as dominant word associations. When dominant associates could not be used (e.g., when different stimulus words elicited the same dominant response), the second most-frequently-occurring response to the stimulus word was used. Uncommon responses were defined as responses having an associative frequency between 10 and 15 in the Minnesota norms. Further, all common and uncommon response pairs had Thorndike-Lorge frequencies of 24 per million or greater in the G Count, and no stimulus word or response word was used more than once. Following the presentation of the forced-choice list, a free-association list was presented to all *Ss*. This second list consisted of 24 stimulus words taken from the Minnesota norms which had Thorndike-Lorge frequency counts above 24 per million and which were not used as stimulus words in the forced-choice list.

3. Procedure

Normal *Ss* were tested in a mobile laboratory, while retardate *Ss* were tested in a room on the institution grounds. When tested, *S* sat at a table facing *E*, a male graduate student 24 years of age. *S* was told that he was going to play a "word game" and was asked, for each of the forced-choice items, to tell *E* whether the second word or the third word went "best" with the first word. *E* gave several examples to be sure that *S* understood the instructions. *E* also emphasized the point that the game was "not a test of any kind and the results of the game will be known only to me and will not become part of your school record."

The experimental design was a three-by-three factorial with three treatment

TABLE 1
DESCRIPTION OF SUBJECTS

<i>MA</i>			<i>CA</i>			<i>IQ</i>			Length of institutionalization		
<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range
<i>Low-MA Group (N = 30)</i>											
6.02	.40	5.00-6.50	22.42	5.45	15.58-34.08	43.60	6.01	40- 67	12.03	7.09	3.42-27.67
<i>High-MA Group (N = 30)</i>											
7.56	.73	6.58-9.17	25.01	6.51	15.75-34.92	52.63	8.65	45- 70	13.39	7.32	3.42-29.50
<i>Normals (N = 51)</i>											
7.61	.65	6.42-8.75	7.12	.75	6.08- 9.33	112.68	7.74	95-127			

conditions orthogonal to three subject groups. Within each of the subject groups, control Ss were given no verbal reinforcement. Experimental Ss were given no verbal reinforcement during the first 15 trials of the training phase. Thereafter, whenever Ss in the two experimental groups selected the uncommon-word and common-word associates of the remaining 50-item list respectively, they were reinforced by *E*'s saying "good." The presentation of the stimulus sequences was randomly determined prior to the experiment, as was the order in which each common response and uncommon response followed its stimulus word. All Ss received the same resulting sequence of items. For each *S*, *E* read aloud the stimulus sequences and recorded *S*'s verbal choices. When *S* failed to follow instructions on one or more of the forced-choice items (e.g., *S* responded with a word not presented by *E* or gave the stimulus word as a response), *E* told *S* that he "could not give this word as an answer." *E* then repeated the instructions and presented the stimulus sequence again.

Upon completion of the forced-choice list, a 24-word free-association list was given. *E* read the stimulus words aloud and recorded *S*'s responses. If *S* failed to respond within 12-seconds, *E* recorded an omission. If *S* failed to follow instructions on the free-association task (e.g., if *S* repeated the stimulus word), *E* repeated the stimulus word and called for another response. Finally, *S* was asked three questions: (a) what was the game all about? (b) what did one have to do to win the game? and (c) had *E* said anything that influenced *S*'s answers?

C. RESULTS

1. *Forced-Choice List*

The major dependent variable in this analysis is the percentage of unique responses selected. Table 2 summarizes the major findings. An analysis of variance of the arcsin transformed percentage of unique response choices on the operant level shows that before experimental treatment the subject group variable was the only significant source of variance ($F = 41.31$; $df = 2, 102$; $p < .001$). The results of two-tailed t tests indicate that the normal children chose significantly fewer unique responses on the operant level than did the High-*MA* retardates ($p < .01$) who, in turn, chose significantly fewer unique responses than did the Low-*MA* retardates ($p < .01$).

Based upon z scores, the per cents of *common* responses selected by the various groups were as follows: 86 (normal subjects), 73 (High-*MA* Group), and 57 (Low-*MA* Group). Each of the foregoing per cents differs significantly from a chance value of 50 per cent ($p < .05$).

An analysis of variance of the arcsin transformed percentage of unique response choices on the last 15 trials indicates that subject groups and reinforcement conditions are significant sources of variance. For subject groups, $F = 11.02$ ($df = 2, 102$; and $p < .01$). For reinforcement conditions, $F = 3.31$ ($df = 2, 102$; and $p < .05$). Analysis of the means for the subject groups yields results identical with those obtained in the operant-level analysis; i.e., Ss in the Low-*MA* Group selected more uncommon responses than did Ss in the High-*MA* Group, who selected more uncommon responses than did Ss in the normal group. Individual t tests of the treatment means indicate

TABLE 2
FORCED-CHOICE AND FREE-ASSOCIATION SCORES

Reinforcement condition	N	Forced-choice percentage of unique responses (arcsin transformed)				Free-association scores	
		Operant level		Test		M	SD
		M	SD	M	SD		
<i>Low-MA Group</i>							
Uncommon responses	10	37.11	9.28	35.71	10.72	86.30	63.18
Common responses	10	39.65	9.62	37.17			
Control	10	44.53	9.07	41.68	5.02	125.54	52.03
					9.31	63.70	52.17
<i>High-MA Group</i>							
Uncommon responses	10	29.07	8.66	31.46	8.03	146.44	65.25
Common responses	10	30.53	10.59	31.90	7.14	159.58	64.22
Control	10	30.52	13.03	38.19	8.05	127.14	80.79
<i>Normals</i>							
Uncommon responses	17	19.43	8.95	31.09	9.39	181.86	57.77
Common responses	17	21.21	7.30	26.48	6.27	218.59	73.10
Control	17	22.45	8.36	30.63	8.62	194.24	48.93

that Ss reinforced for selecting common-word associates made significantly fewer uncommon-response choices than did Ss given no verbal reinforcement ($p < .02$). Other mean differences fail to reach statistical significance. An analysis of covariance, adjusting for operant-level performance, yields comparable results both for subject groups and reinforcement conditions ($r = .31$).

Additional analysis for the final 15 trials of forced-choice responding shows that the mean per cents of *common* responses are 76 for normal subjects, 68 for the High-*MA* Group, and 61 for the Low-*MA* Group. Each of the foregoing per cents differs significantly from a chance value of 50 per cent ($p < .001$).

2. Free-Association Transfer List

S's free-association responses were scored by assigning frequency scores culled from the Minnesota norms (7), and the mean frequency of each S's

responses was computed. A low score indicates a tendency to give uncommon responses.

Table 2 summarizes the major results. An analysis of variance indicates significant effects for subject groups ($F = 26.54$; $df = 2, 102$; $p < .001$) and for treatment conditions ($F = 3.47$; $df = 2, 102$; $p < .05$). The results of t tests indicate that Ss in the Low-*MA* Group gave significantly more uncommon-word associations than did Ss in the High-*MA* Group ($p < .01$), and that Ss in the High-*MA* Group gave more uncommon associations than did Ss in the normal group ($p < .01$). The results of t tests for the treatment means show that Ss reinforced for common-word associations gave significantly more common-word associations than did Ss in the other two groups ($p < .05$). Other differences fail to reach statistical significance.

Many Ss obtained scores of zero, and a chi-square analysis for the omission data shows that significantly more Ss in the Low-*MA* Group and the High-*MA* Group than in the normal group failed to respond to one or more of the stimulus words ($p < .001$). The two retardate samples, however, did not differ significantly from each other. Thirty per cent, 10 per cent, and zero per cent of the Ss in the Low-*MA* Group, High-*MA* Group, and normal group, respectively, failed to respond to one or more of the stimulus words.

In Maltzman, Simon, and Licht's study (4), Ss reinforced for common responses received significantly more reinforcements than did Ss reinforced for uncommon responses, and the authors attribute this result to the fact that the relatively infrequent occurrence of uncommon responses in the general sample limits the opportunity for reinforcement. With retardates as Ss, the present study can examine the extent to which Ss whose operant level for giving uncommon responses is relatively high receive greater numbers of reinforcements when verbally reinforced for giving uncommon responses. A two-by-three analysis of variance of the mean number of reinforcements received yields significant F ratios for subject groups ($F = 4.02$; $df = 2, 68$; $p < .05$), reinforcement conditions ($F = 234.19$; $df = 1, 68$; $p < .001$), and for group-by-condition interaction ($F = 17.29$; $df = 2, 68$; $p < .001$). In agreement with the results reported by Maltzman, Simon, and Licht, Ss receiving reinforcement for common-word associations received significantly more reinforcements than did Ss receiving reinforcement for uncommon-word associations. Further, Ss in the Low-*MA* Group and in the normal group received significantly more reinforcements than did Ss in the High-*MA* Group, but the first two groups did not differ significantly from each other. Figure 1 shows the nature of the significant interaction. When Ss were reinforced for uncommon responses, retardate Ss received significantly more reinforcements than did Ss in the normal group ($p < .01$ and $< .05$); but the

two retardate groups did not differ reliably from each other. When *Ss* were reinforced for common responses, *Ss* in the normal group received significantly more reinforcements than did retardate *Ss* ($p < .01$). In addition, *Ss* in the Low-*MA* Group received significantly more reinforcements than did *Ss* in the High-*MA* Group ($p < .05$).

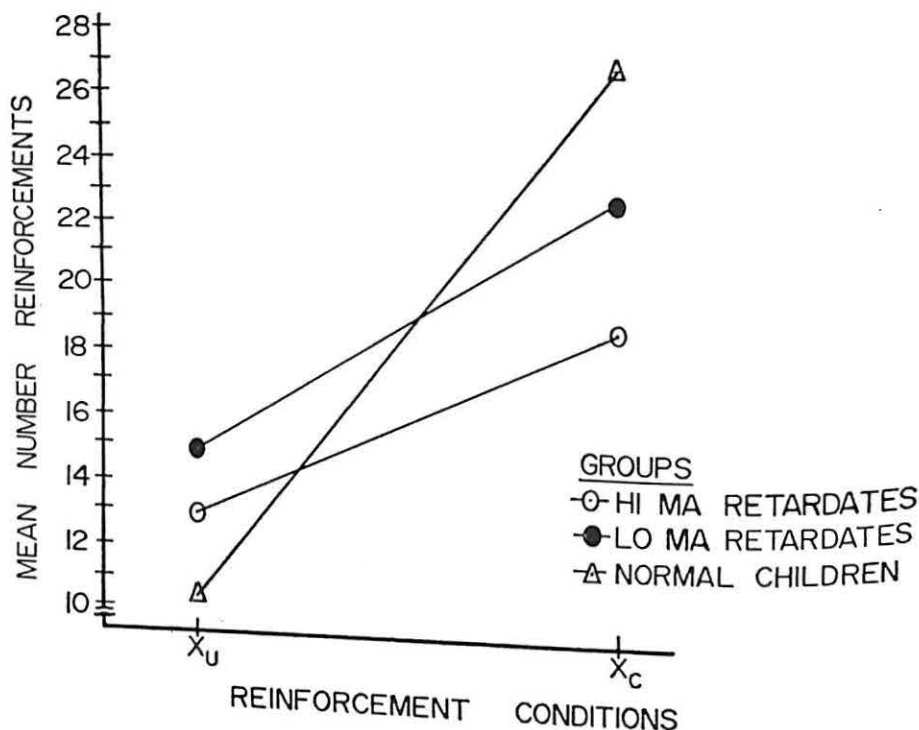


FIGURE 1
MEAN NUMBER OF REINFORCEMENTS RECEIVED BY SUBJECT GROUPS UNDER
DIFFERENT REINFORCEMENT CONDITIONS

3. Correlational Analyses

For both normals and retardates, neither age nor sex is significantly correlated with associative behavior. For the retardates, length of institutionalization shows no correlation with the forced-choice or the free-association behavior; but each of these behaviors is significantly related to *MA* level: the higher the *MA* level, the fewer the number of uncommon associative operant-level choices ($r = -.47$, $p < .01$) and the greater the number of common free associations on the transfer task ($r = .45$, $p < .01$). For normal subjects, the direction of the relationships between *MA* and associative responding

tended to be in the same direction as for retardates; but the coefficients were not significant. No *S* in either the retardate or normal populations could verbalize the reinforcement contingency, and no *S* indicated that *E* had influenced the responses in any way.

D. DISCUSSION

The results of the present study indicate that retardate and normal *Ss* given verbal reinforcement for selecting common responses on a forced-choice verbal task choose significantly more common responses on a subsequent forced-choice task than do comparable groups of *Ss* given no verbal reinforcement for their selections. Further, this behavior transfers to a free-association task. These results agree in general with those reported by Sommer, Witney, and Osmond (9) and by Maltzman, Simon, and Licht (4). The fact that each of the two studies just cited made use of a free-response task during reinforcement trials, rather than of the forced-choice procedure used in the present experiment, implies that the reinforcement generalizes across different stimulus conditions.

The facilitation effects obtained when reinforcement was given for common-word associations occurred in the absence of reports by the *Ss* that *E* had influenced the responses. This finding conflicts with results reported by Maltzman, Simon, and Licht (4), who found no significant increase in common responses in the absence of the ability by *Ss* to verbalize the reinforcement contingency. The authors of other verbal-conditioning studies employing young children as *Ss* (1, 6) report facilitation effects in the absence of "awareness." As suggested by Baer and Goldfarb (1), level of awareness in studies using operant verbal-conditioning procedures may have a differential influence in facilitating acquisition of particular response classes for *Ss* of varying ages.

The present authors' finding that the reinforcement of uncommon responses does not facilitate criterion responding is also in agreement with the results reported by Maltzman, Simon, and Licht (4). As indicated earlier, the authors just mentioned suggest that one reason for failure to obtain facilitation when uncommon-word associations are reinforced is the relatively low operant level of responding for this class of responses; hence there is less probability of obtaining reinforcement for their occurrence. It should be clear, however, that this factor alone cannot account completely for the failure of retardate *Ss* reinforced for uncommon associations to show significant facilitation effects because the operant level for giving uncommon responses is *relatively* high in such *Ss*. As the results indicate, when uncommon associations were reinforced,

retardate Ss received significantly more reinforcements than did normal children. Further, to determine whether or not the number of reinforcements *per se* is a significant variable in facilitating associative responding, the authors computed product-moment correlations between the number of reinforcements given under each reinforcement condition (within each of the subject groups) and free-association transfer-list performance. None of the correlations was found to be significant; therefore, within the limits of the present experiment, it seems that the facilitation of associative responding under conditions of verbal reinforcement cannot be related in simple fashion to the number of reinforcements given.

A puzzling aspect of our results is the fact that for Ss in the Low-*MA* Group differences between operant-level and test-level forced-choice performance show control Ss and Ss reinforced for common responses to be comparable; thus main-effect differences between the two conditions just mentioned must be attributed primarily to the performances of Ss in the High-*MA* Group and normal group. Inasmuch as the reinforcement of common responses seems in the Low-*MA* Group to have no effect beyond that to be expected by presenting Ss with unreinforced forced-choice items, it is difficult to understand why Ss of this group (when given reinforcement for common responses) gave more common responses on the free-association test list than did normal Ss. Because number of reinforcements does not correlate significantly with free-association responding, one explanation may be that reinforcement for common responses *per se* is a sufficiently potent variable to yield differential transfer effects on the free-association list.

The fact that sex and length of institutionalization are not significantly correlated with associative behavior in retardates is in general agreement with results reported by Silverstein and McClain (8). Silverstein and McClain also report significant positive correlations between number of common responses given by retardates and *IQ*. The significant positive correlations between *MA* in retardates and associative responding obtained in the present study appear to be consistent with these results.

Finally, the significant group differences obtained on all of the associative measures deserve mention. Operant-level and test-level forced-choice performance differences, as well as free-association performance differences, indicate that associative norms derived from a normal-adult population can reliably discriminate between retardate Ss at two *MA* levels, as well as between retardates and normal children.

E. SUMMARY

Two populations of retardates (a High-*MA* Group and a Low-*MA* Group) and a population of normal school children were verbally reinforced for saying certain words in a 65-item forced-choice associative task. Within each of the three subject populations, certain Ss were given reinforcement for selecting common words; others, for selecting uncommon words. Control Ss were given no reinforcement for their selections. Performances on the last block of forced-choice trials and on a free-association transfer task constituted the criterion tasks of major interest.

Results indicate that for High *MA* retardates and normal Ss reinforcement of common responses facilitates criterion responding. No other significant differences between experimental conditions were obtained. For both retardates and normals, significantly more reinforcements were received by Ss when common responses were reinforced than when uncommon responses were reinforced. Retardate Ss received significantly more reinforcements than normal Ss when reinforced for uncommon responses, and normal Ss received significantly more reinforcements than retardate Ss when reinforced for common responses. No significant correlations were found between number of reinforcements given and free-association transfer-task performance. Additional correlations show insignificant relationships between associative responding and *MA*, age, sex, and length of institutionalization. *MA* level correlates significantly with associative responding only for retardates.

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THE LEARNING OF DOUBLE ALTERNATION BY CHILDREN AND ADULTS UNDER DIFFERENT TRAINING PROCEDURES*

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A. INTRODUCTION

In an attempt to throw light on the process mediating the learning of double alternation, Schoonard and Restle (2) compared two methods of presentation. Under one method (stimulus-pattern) *S* was confronted with a fixed pattern of double-alternating stimuli (*E* saying "plus, plus, check, check," etc.) and was required to anticipate each stimulus event. Under the other method (response-pattern), there was no fixed pattern in the stimulus events; instead, whether *E* said "plus" or "check" was determined by what *S* had anticipated on the two previous trials, so that *S* would anticipate correctly whenever his pattern of responses double alternated and would fail to do so whenever he deviated from a double-alternating pattern of responses.

In both situations, *S* must respond to the outcomes of the two previous trials. In one case, however, he must respond to the stimulus events and may ignore his own responses; in the other he must respond to his own responses and may ignore the stimulus events. To the extent that *S* performs better under one condition, it would appear that he responds to one set of cues rather than to the other.

Schoonard and Restle, using two samples of college students, found a marked difference in favor of the stimulus-pattern condition. The present investigation was an attempt to replicate Schoonard and Restle's findings, but with visual stimuli instead of verbal stimuli, and with children as well as with adults.

Because the learning of double alternation has been widely used as a comparative measure of symbolic activity, it is important to establish that the species under comparison respond to similar cues. Both methods of presenting the problem would seem to require some kind of symbolic-mediating response. Under stimulus patterning, *S* has to remember the two previous stimuli; under

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response patterning, the two previous responses. In neither case can double-alternating behavior be explained in any obvious mechanical way.

Unless it can be shown that in the double-alternation learning situation the groups under comparison respond to the same sorts of cues, the status of double alternation as a reliable and valid technique for assessing different levels of symbolic activity will be in question.

It is known that in the stimulus-pattern situation adults learn double alternation more readily than children (1), and this superiority is attributed to a higher level of symbolic activity; however, unless adults can be shown to perform better in the response-pattern situation too, this assumption will be open to doubt.

B. METHOD

1. *Subjects*

Forty children and 40 adults served as Ss. The children, each 11 years of age, were drawn from an Adelaide Primary School; the adults were first-year psychology students at the University of Adelaide. Half the children and half the adults learned under the stimulus-pattern procedure; half under the response-pattern procedure. There were 10 males and 10 females in each subgroup, but one of the children assigned to the stimulus-pattern group made no errors; so his results are excluded from analysis.

2. *Procedure*

S was seated in front of a screen on which three lights were mounted: one on the right of the screen, one on the left, and one in the center and near the top. The top-center light was red; the side lights were white. Below each side light was a Morse key wired to a light on the opposite side of the screen. On each trial, the red light was activated for three seconds, then shut off, and two seconds later one of the other lights was activated for one second. S was instructed to press one of the Morse keys while the red light was on—his object being to guess which of the two lights would be activated next. E, concealed from S, controlled the lights and recorded S's responses.

For the stimulus-pattern groups the first response was always rewarded, so that the lights were activated in llrrllrrll . . . sequence or in rrrllrrllr . . . sequence.

For the response-pattern groups the first response was always rewarded; the second was rewarded only if it was the same as the first; thereafter, only responses which were the opposite of the last but one were rewarded. Clearly, a S who made no errors could not meaningfully be assigned to either group.

The criterion for learning was 20 consecutive correct responses, and the limit for nonlearners was 200 trials.

C. RESULTS

The results imply that adult Ss find the task easier with stimulus patterning than with response patterning. All of the adult Ss in the stimulus-pattern group learned within 60 trials, whereas six of the 20 in the response-pattern group failed to reach criterion in 200 trials. There was little difference between the two groups of children. In the stimulus-pattern group, four of 19 children failed to learn; in the response-pattern group, five of 20 failed. The means, medians, and ranges for the four groups (based on the trial of the last error) are given in Table 1.

TABLE 1
TRIAL OF LAST ERROR FOR ADULT AND CHILD STIMULUS-PATTERN (S) AND
RESPONSE-PATTERN (R) GROUPS

Group	Trial of last error		Range
	Mean	Median	
Adult S	10.2	6.5	2-60
Adult R	94.9	77.0	5-200
Child S	59.6	23.0	2-200
Child R	82.9	49.0	6-200

On a median test, the four comparisons (adults *vs.* children under each condition, and stimulus pattern *vs.* response pattern for both adults and children) reveal a significant difference in favor of the adults ($p = .038$) on the stimulus-pattern task; no difference between adults and children on the response-pattern task; a significant difference between the stimulus-pattern task and the response-pattern task for the adults ($p < .00004$); and an insignificant difference between the two tasks for the children.

Schoonard and Restle (2) hypothesized that under the response-pattern condition Ss who experience a relatively high proportion of double alternations in the event series tend to learn more quickly than others. Defining a run as five consecutive double-alternating events, such as rllrr, llrrl, etc., and more than five consecutive double-alternating events as overlapping runs (e.g., six would count as two runs, seven as three runs) Schoonard and Restle calculated an index for each S: $r/(n-4)$ where r is the number of runs, and n the number of trials to criterion. Because none of the first four trials can mark the end of a run, four is subtracted from the number of trials. Presumably, this prediction applies equally to adults and children; so there seems no justification for separating the groups in the analysis. The mean of this

index for the 29 learners is .212 ($SD = .188$); for the 11 nonlearners, .181 ($SD = .082$). The difference is in the predicted direction, but it does not seem appropriate to calculate a t value owing to the nonhomogeneity of the variance. The nonhomogeneity is to be expected because the values for non-learners are based on larger N s than those for learners.

A more satisfactory way of testing Schoonard and Restle's hypothesis would be to show a negative correlation between trials to criterion and the value of the index. Because the assumption of homoscedasticity cannot be met, a Spearman rank-difference correlation coefficient was computed and found to be .027. This result does not support Schoonard and Restle's hypothesis.

The results were also analysed in terms of S 's initial tendency to repeat or to alternate. Of the adults, 24 (out of 40) repeated their initial response; of the children, 10 (out of 39) repeated their initial response. This difference in frequencies yields a chi square of 9.5 ($p < .01$ for a two-tailed test); however, the tendency to repeat or to alternate from the initial response does not appear to be related to performance.

Another measure that seemed of potential interest was the proportion of runs in each S 's response series, but this measure is unrelated either to the initial tendency to repeat or to performance, and it does not differ between children and adults or between stimulus-pattern and response-pattern groups.

D. DISCUSSION

The results for adult S s are similar to those obtained by Schoonard and Restle despite the fact that visual stimuli instead of auditory stimuli were used; however, the performance of the children implies that the process mediating the learning of double alternation in children is different from the process in adults. Whereas the adults demonstrated a strong tendency to rely on cues from previous stimuli rather than from previous responses, the children showed no such tendency.

It seems appropriate, therefore, to consider the possibility that species differences in the learning of double alternation may be due not entirely to differences in the ability to use symbols but also to preferences for stimulus cues as opposed to preferences for response cues.

E. SUMMARY

The learning of double alternation by children and adults was compared, using different methods of presentation. Under stimulus patterning, S s were required to anticipate events that occurred in a fixed double-alternating

sequence. Under response patterning, the stimulus events were contingent on S's previous responses.

The adults performed better under the stimulus-pattern condition than under the response-pattern condition, but the children performed equally well under both. This suggests that the mechanism underlying the learning of double alternation is different in children and adults and may also differ between species. If so, doubt is cast on the status of double-alternation learning as a reliable and valid measure of interspecies differences.

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EFFECT OF ACTH ON OPEN-FIELD BEHAVIOR, AVOIDANCE,
STARTLE, AND FOOD AND WATER CONSUMPTION* 1 2

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A. INTRODUCTION

The clinical administration of adrenocorticotrophic hormone (ACTH) has resulted in a variety of behavioral and psychological side effects. These effects have included euphoria, increased general sensitivity, increased alertness, increased tension, tendency to hyperactivity, insomnia, decreased fatigue, ravenous appetite, anxiety, and (in about five per cent of the cases) outright psychosis. [Summaries of these effects are given in Goolker and Schein (5), Fox and Gifford (3), Glaser (4), and McLaughlin, *et al.* (8).]

Attempts to determine the effects of ACTH on behavior, using animals, are at best confusing. Mirsky, Miller, and Stein (9) reported that when ACTH was given to monkeys during a fear-training situation, the monkeys showed far less fear during extinction than did monkeys trained without ACTH. However, Murphy and Miller (12), using rats, showed that ACTH had no effect on the learning of an avoidance response; but Ss given ACTH during acquisition took significantly *longer* than other rats to extinguish.

Attempts to study the problem by reducing the ACTH output are even more confusing. Applezweig and Baudry (1) showed that hypophysectomy significantly interferes with the acquisition of an avoidance response, but Belanger [quoted in Bindra (2, pp. 264)] found no difference between the avoidance-response acquisition rate of hypophysectomized rats and normal rats.

Levine and Soliday (7) destroyed the median eminence of the tuber cinerium, which blocks the release of ACTH, and found that such Ss learned an avoidance response significantly faster than normal Ss.

The current study was undertaken to assess the effect of a variety of ACTH doses on a range of behaviors that clinical results and previous studies indicate

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might be influenced by that hormone. The dependent variables are open-field behavior, the startle response, food consumption, and water consumption. Avoidance training was initiated after the termination of ACTH treatment, in an attempt to obtain some estimate of the effect of ACTH deficiency on avoidance learning. It is known that continued treatment with ACTH results in the clinical signs of adrenal-cortical insufficiency when the ACTH is withdrawn. This is presumed to be due to the suppression of corticotropin secretion by exogenous ACTH [see Ingle and Baker (6)].

B. METHOD

1. *Subjects*

Eighty-six naive male albino rats from the colony of the Carnegie Institute of Technology served as Ss. All Ss were 80 to 105 days of age at the beginning of the experiment.

2. *Apparatus*

The open-field apparatus consisted of an enclosure 23" $\times$ 33" with 15-inch sides of composition board painted gloss white. The floor, covered with acetate, was white and divided (by three-sixteenth inch black lines) into equal-sized rectangles ($4\frac{1}{2}$ " $\times$ $3\frac{1}{4}$ "). A 200-watt bulb was placed 23 inches above the floor.

The startle apparatus has been described elsewhere (10). It consisted of a sensing unit made from a postage scale (Hanson Model 1509 five-pound capacity), with the platform being replaced by a confining box. When S was placed in the confining box and subjected to a sharp auditory stimulus, the startle reaction caused the platform to be depressed. The downward movements of the platform were transmitted (by a thread-and-pulley system) to a lever-recording pen on a Phipps and Bird recorder. The startle stimulus was produced by a six-mm blank starting pistol held 48 inches from S.

The floor of the confining box consisted of one-eighth inch brass rods spaced one-half inch on center. The avoidance box, described elsewhere (11), consisted of a battleship-gray alley two and one-half feet long, 10 inches wide, and 16 inches high. It was divided into equal compartments by a partition suspended five inches above the grid floor. An Applegate Stimulator, Model 228, was used to charge the grids. A seven and one-half watt frosted light bulb was hung 24 inches above the center of each compartment, and a buzzer was mounted on the apparatus behind the center of the box. Control apparatus in another room automatically timed and presented the events in the avoidance box and recorded the latencies and types of responses.

Calibrated tubes, which could be read accurately to one-half ml, were used to measure water consumption.

C. PROCEDURE

Five days prior to the first experimental day, *Ss* were placed in individual cages with calibrated water bottles and were given food and water *ad libitum*. On the first experimental day, each *S* was weighed and randomly assigned to one of six groups. The four experimental groups were given daily subcutaneous injections of ACTH in the following dosages: Group I—0.125 USP/100 gm; Group II—0.25 USP/100 gm; Group III—0.5 USP/100 gm; Group IV—1.0 USP/100 gm. Group V received control gelatin containing no ACTH and served as an injected control group. Group VI received no injection and was the noninjected control group. Throughout the experiment the *Ss* had free access to both food and water 23 hours per day. Injections were given, and food and water measurements were made during the 24th hour. Injections were given for 10 consecutive days, but food and water consumption were measured for 20 days.

Beginning the fifth day of injections, three hours after the injection, all *Ss* were given experience in the open field according to the following procedure: *S* was taken to the testing room in its own cage. It was then placed in the center of the open field, and record was made of the number of rectangles entered during a four-minute period. *S* was then removed from the open field and returned to its cage, and record was made of the number of fecal boluses produced. The sides of the field were then removed and the acetate floor was washed with warm soapy water, rinsed with clear water, and dried with a towel. This procedure was followed for five days. On each of these days a record was also kept of the number of boluses produced in the 23-hour period in the home cage.

On the 10th day of injections, three hours after the injections, all *Ss* were startled according to the following procedure: *S* was taken to the startle room, placed in the confining box of the apparatus, and given 1.5 minutes of acclimatization time. The blank pistol was then fired. The initial shot served to settle *S* down. Characteristically, *S* ceased all random movement and remained quite still on all four feet in the cage and did not change position appreciably during the rest of the trial. At intervals of 30 seconds, five more shots were fired; and the amount of startle was automatically recorded. Thirty seconds after the last shot, a shock of 0.1-second duration and 2.5 ma was applied to the grid floor of the apparatus. Thirty seconds later, shock was applied again. The startle response was recorded both times.

On the day after injections were terminated, *Ss* were weighed. On the second day after the termination of injections, *Ss* were started on avoidance training according to the following procedure: At the beginning of training, the light over the right-hand grid was on. *S* was placed on the lighted grid facing away from the dark grid. On the first trial, the buzzer sounded, the light over the right grid went out, and (at the same time) the light on the left grid went on. After a five-second interval, the dark grid was charged with a 50-volt, three-ma shock, and shock remained on the dark grid until the beginning of the next trial. The buzzer was terminated as soon as *S* ran to the lighted grid. On each subsequent trial, the light shifted, the buzzer sounded, and the entire grid was free of shock for a five-second period, followed by shock on the dark grid. The intertrial interval was varied from 10 to 30 seconds unsystematically, with a mean interval of 20 seconds. Each *S* received 30 trials per day.

An avoidance response was defined as a response of crossing from the dark grid to the lighted one within five seconds of the presentation of the buzzer and the changing of the lights. On such a response, *S* did not receive shock. If *S* delayed responding more than five seconds, it received shock; and the response was defined as escape. Spontaneous crossings (i.e., between trials) dropped out quickly because the dark grid was always charged between trials. *Ss* were given four days of training. On the fifth day there was an extinction procedure exactly the same as the training procedure except that no shock was used. *S* met the extinction criterion when it failed to respond three times in any 10 trials.

D. RESULTS AND DISCUSSION

An analysis of variance on each of the dependent variables indicates that the groups do not differ significantly on any of the measures used. Table 1 gives the means for each group for each variable (except per cent avoidances) and the resulting *F* from the analysis of variance.

Table 2 shows the mean per cent avoidance for each group on each day. An analysis of variance (groups by days) shows *F* for days to be significant beyond the .01 level ($F = 187.51$), indicating that the avoidance response was learned. The *F* for groups is .30; for groups-by-days interaction it is .88. Neither of these *F*s is significant, indicating that the ACTH injection had no discernible effect on the learning of the avoidance response.

Although clinical reports and previous experiments indicate that the dependent variables examined might be influenced by exogenous ACTH, such indications are not supported by the data. In spite of the fact that a relatively

TABLE 1
MEAN SCORES FOR ALL GROUPS ON ALL DEPENDENT VARIABLES AND *F* RESULTING FROM ANALYSIS OF VARIANCE

Measure	Group					Noninjected control	<i>F</i>
	0.125 USP ACTH	0.25 USP ACTH	0.5 USP ACTH	1.0 USP ACTH	Injected control		
Initial weight (in gms)	284.9	289.3	284.0	284.4	291.8	289.1	*
Weight after 10 injections (in gms)	300.8	297.1	284.8	296.3	320.2	315.8	*
Mean 10-day food consumption (in gms)	20.2	20.0	18.9	20.4	20.7	21.7	1.52
Mean 10-day water consumption (in ml)	32.2	33.6	31.1	33.2	34.3	35.4	1.04
Mean open-field activity	66.3	73.4	64.8	51.5	77.3	63.8	1.59
Mean open-field boluses	2.2	2.7	3.1	2.1	2.7	2.2	0.71
Mean home-cage boluses	41.9	41.8	39.6	40.1	40.5	41.4	0.39
Mean startle to shot (in mm)	3.5	3.7	4.6	4.6	2.9	4.0	0.50
Mean startle to shock (in mm)	5.0	8.2	6.2	8.5	7.9	9.6	1.07
Mean extinction	22.6	17.2	28.3	12.1	10.9	11.5	0.67

* In a groups-by-days analysis, groups do not differ significantly ($F = .80$), and the groups-by-days interaction is not significant ($F = 2.15$). Days are significant ($F = 25.71$) indicating that there was a weight gain over the 10-day period.

wide range of doses was used, no significant difference attributable to ACTH appeared. The possible reasons for no difference are, of course, legion; however, this study may serve as a guide for further investigation on the influence of ACTH on behavior by indicating which variables not to investigate or, at least, some of the parameters not influenced by ACTH.

TABLE 2
MEAN PER CENT AVOIDANCE FOR EACH GROUP FOR EACH DAY

Day	Group					Non-injected control
	0.125 USP ACTH	0.25 USP ACTH	0.5 USP ACTH	1.0 USP ACTH	Injected control	
1	8.8	15.7	9.7	16.6	9.7	12.6
2	40.4	38.4	36.8	40.5	30.2	46.2
3	58.2	59.7	54.7	57.4	51.2	59.0
4	67.3	68.4	70.9	64.5	54.3	58.4

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SUBJECT EMOTIONALITY AND SUSCEPTIBILITY TO ENVIRONMENTAL STRESS*¹

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A. OBSERVATION

Animals judged as highly emotional by the Hall open-field test (7) are reported to perform differently from nonemotional animals in various behavioral-test situations. Investigators working with the Maudsley reactive and nonreactive (i.e., emotional and nonemotional) rat strains have reported superior performance for emotional rats in the acquisition of a passive-avoidance response (10, 13). On the other hand, nonemotional rats are superior in the acquisition of an active-avoidance response (2, 8, 10). Freezing and crouching responses are characteristic behaviors of the reactive strain when these rats are placed in an emotion-provoking situation (1). Because freezing and crouching responses inhibit the motor responses required by an escape-avoidance learning task, reactive rats manifest poorer active-avoidance behavior but superior passive avoidance, because the latter demands the inhibition of ongoing behavior. The foregoing suggests that emotional organisms are inferior in adaptive and efficient behavior when placed in a novel or stress situation. This contention is supported by Yarkin and Eysenck (17), who observed inferior acquisition by emotional rats in a bar-pressing situation. The hypothesis may be advanced that emotional organisms are more susceptible than others to the deleterious effects of environmental stress.

The purpose of the present study was to investigate the relative susceptibility of emotional rats and nonemotional rats to chronic environmental stress. An animal was judged to be susceptible in terms of body-weight loss and stomach ulceration.

B. MATERIALS AND METHOD

1. *Subjects*

One hundred eight male Sprague-Dawley rats were used during the pre-experimental period. All Ss were obtained from the Charles River Breeding

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Laboratories, Brookline, Massachusetts, when *Ss* were approximately 40 days old. They were housed in large cages (each cage containing 10 rats), and an *ad libitum* feeding schedule was in effect while group-living conditions prevailed. When *Ss* were 85 to 100 days old, they were separated and placed in individual cages. Ten days later, testing procedures were initiated. From the original 108 *Ss*, 48 were selected for the experimental-stress period.

2. Apparatus

The apparatus used to determine emotionality was a modification of Hall's open-field apparatus (7). The open field had a white floor 45" $\times$ 32", with white walls 18 inches high. Thin black lines divided the floor into eight-inch squares, a 200-watt bulb was suspended 32 inches from the middle of the floor, and the apparatus was situated in a sound-shielded room. The sound from a ventilator blower, which measured 32 db from the middle of the open field, was used as a masking sound. *S's* behavior in the open field was recorded by *E* by means of silent toggle and push-button switches.

Rats were subjected to chronic stress in individual chambers, which consisted of grid boxes seven inches wide, eight inches deep, and seven inches high. All walls were wood except the plastic front door. A small speaker was attached beyond a two-inch hole in the ceiling. A plastic box containing food was attached outside the door. *S* was able to eat by poking his head through matching holes in the door and the food box. The arrangement allowed for feeding, but prevented food spillage. A water cylinder, with a drinking spout protruding into the chamber, was also attached to the door. The floor consisted of 2/16-inch brass rods spaced one-half inch apart. Each stress chamber was placed inside a ventilated picnic cooler. With the cooler doors closed, the chambers were isolated from one another with respect to sound. A Model SS13 Scientific Prototype shock source and scrambler was used to charge the chamber grids. A Model 377 Eico audiogenerator supplied the tone stimulus. Presentation of stimulus events was controlled by a Gerbrands tape programmer.

3. Procedure

a. Open-field testing. During open-field testing, all *Ss* were housed in individual home cages. The open-field procedure, described elsewhere (9), consisted of placing *Ss* individually in the open field for a four-minute test period. Ambulation was recorded in terms of the number of squares that *S* traversed with four feet, and after the four-minute test period *S* was returned to its home cage. The number of boluses was recorded, the floor and the walls

were washed after each trial, and all Ss were given one trial at the same time each day for four days.

On the basis of defecation and ambulation scores, all Ss were ranked. Animals in the initial ranks were designated as low-emotional Ss, and animals in the terminal ranks were designated as high-emotional Ss. These two groups were further subdivided into stress and control groups, creating four groups of 12 Ss each.

b. Stress period. All 48 Ss were placed in individual stress chambers for a seven-day habituation period. The stress period, started on the eighth day, consisted of a four-second 2000-cps CS tone followed immediately by a 1.5-second, 2.0 ma shock presented with an average time interval between tone-shock pairings of four minutes. The stress schedule lasted 20 hours daily for 22 days.

The emotional control group and the nonemotional control group did not receive tone and shock stimulation, but remained in their respective chambers throughout the experiment. In this respect, the stress period was identical to the habituation period for these two groups.

Food consumption and body weight were obtained daily from all Ss during the habituation and stress period. Upon termination of the stress period, all Ss were sacrificed. Adrenal glands were removed and weighed on a Mettler analytical balance. Stomachs were removed, cut along the greater curvature, and inspected under a dissecting microscope. Stomach condition was classified according to three categories: negative, no evidence of erosion or gastritis in any part of the stomach; Stage I, loss of stomach mucous and presence of clotted blood; and Stage II, Stage I conditions plus presence of hemorrhagic erosions in either the body or the rumen of the stomach.

C. RESULTS

An attempt was made to estimate the reliability of the emotionality classification. In addition to the classification carried out on the basis of the four days of open-field testing, all Ss were rank ordered after the first, second, and fourth day of testing; hence all Ss were independently ranked three different times, and rank-difference correlation coefficients were computed between the first and fourth and the second and fourth testing sessions. The former resulted in a rank-difference correlation of .87 ($p < .01$); the latter, .90 ($p < .01$). Further, inspection of the rankings shows that the same animals occupy the initial 24 ranks (i.e., low-emotional group) for all three classifications. Only two Ss are dropped from the 24 terminal ranks (i.e., high-emotional group), and this occurs only for the rank ordering for the second day. These data

indicate that *Ss*' performance in the open field is consistent for the four-day testing period. Farris and Yeakel (4) have published graphic data illustrating this same consistent performance in the open field for different rat strains over a 12-day period.

The results of the adrenal data are presented in Table 1. The two stress groups manifest a significant adrenal hypertrophy compared to that of controls ($F = 9.65$; $df = 1, 44$; $p < .01$), but significant differences are not observed between emotional *Ss* and nonemotional stress *Ss*. Similarly, a greater incidence

TABLE 1
MEANS AND STANDARD DEVIATIONS FOR ADRENAL-WEIGHT/BODY-WEIGHT
RATIOS FOR THE FOUR EXPERIMENTAL CONDITIONS

Parameter	Experimental conditions			
	Stress		Control	
	Emotional rats	Nonemotional rats	Emotional rats	Nonemotional rats
Mean	.13006	.13664	.11780	.11389
SD	.0193	.0184	.0190	.0148

TABLE 2
NUMBER OF ANIMALS OBSERVED WITH VARIOUS PATHOLOGICAL
STOMACH CONDITIONS

Stomach condition	Experimental treatment			
	Stress		Control	
	Emotional rats	Nonemotional rats	Emotional rats	Nonemotional rats
Negative	4	3	12	12
Stage I	5	7	0	0
Stage II	3	2	0	0

of stomach ulceration is not evident in emotional-stress animals as compared with nonemotional-stress animals. Although the prolonged-stress condition is instrumental in increasing stomach pathology of stress *Ss* ($p < .01$), a significant difference is not observed between the two stress groups (see Table 2).

The tone-shock stress also produces differential body-weight variations for the four experimental groups ($F = 9.91$; $df = 3, 44$; $p < .01$). The significant variation is attributable to the significant weight losses of stress animals. In addition, emotional *Ss* subjected to stress lose significantly more weight than nonemotional *Ss* ($p < .05$), and never regain their prestress weight level. These data are presented in Figure 1 in terms of percentage weight changes. Food consumption was analyzed separately for the habituation and stress periods. There are no differences between groups for the habituation period.

During the stress period, stress *Ss* manifest a significant decrement in food consumption ($F = 7.63$; $df = 3, 44$; $p < .01$), and the emotionally reactive rats subjected to stress eat less than the nonemotional animals ($p < .05$) throughout the entire stress period (see Figure 2).

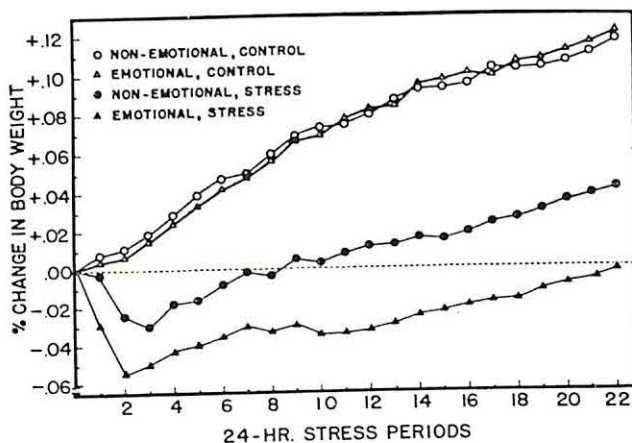


FIGURE 1
MEAN PERCENTAGE BODY-WEIGHT CHANGES DURING THE STRESS PERIOD

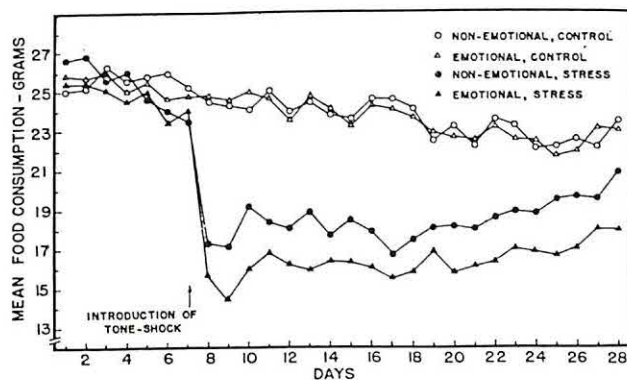


FIGURE 2
MEAN DAILY FOOD CONSUMPTION FOR THE HABITUATION AND STRESS PERIODS

D. DISCUSSION

The adrenal data substantiate the effectiveness of tone-shock pairings as a significant environmental stressor; however, the response of the emotional *Ss* to this stress is equivocal regarding the experimental hypothesis. Whereas emotionally reactive *Ss* lost significantly more body weight, they did not

demonstrate a greater incidence of stomach ulceration. The ulcer data are not in agreement with research findings reported by Sines (11), who found a positive relationship between open-field emotionality and incidence of immobilization-induced stomach lesions. This discrepancy suggests that the etiological factors concerned with immobilization-induced ulcers differ from those associated with fear-induced or anxiety-induced ulcers. This etiological distinction between immobilization ulcers and fear ulcers is also substantiated by Sines, Cleeland, and Adkins (12), who found that animals susceptible to immobilization ulcers were superior in acquiring an active-avoidance response. Because these findings are at odds with studies cited earlier, animals susceptible to immobilization ulcers may represent a different set of constitutional variables.

If emotional animals are more susceptible to environmental stress, this is demonstrated by their greater body-weight loss. The difficulty now is to identify the underlying mechanism responsible for this phenomenon. The thyroid may participate in this response, as Watson (15) and Feuer and Broadhurst (5) have reported thyroid differences in the fifth and 10th generations respectively of the Maudsley reactive and nonreactive strains. Gibson (6), however, in his extensive review, states that stress produces only temporary thyroid inhibition in animals. Although further research on the role of the thyroid in stress may be promising, the present data may be explained from a parsimonious viewpoint. Inspection of the food data reveals that when subjected to environmental stress emotional Ss consume less food than other Ss; and this accounts for the greater body-weight loss of emotional Ss than non-emotional Ss. These results are in accord with those reported by Eysenck (3), who observed a greater decrement in food intake by Maudsley reactive rats than by nonreactive rats when threatened with shock stress. The progressive decrease in food intake throughout the experimental period by control animals is attributable to the cumulative effects of reduced sensory stimulation due to residence in isolation within the picnic coolers. This has also been demonstrated by Weiss and Hurwitz (16).

Since fluctuations in body weight represent a general well-being of the organism, the present study demonstrates that emotional Ss are more susceptible than other Ss to chronic environmental stress. The body-weight loss is an inevitable sequela of their decreased food intake. The question now remains: Why do emotional organisms consume less food when subjected to environmental stress?

A final note of concern is the fact that adrenal and stomach data do not distinguish between the emotional and nonemotional groups. The rank-difference correlations for the various days of open-field testing imply consistency

within groups, and the variables of body weight and food consumption define independent populations; however, a regression effect cannot be excluded. In addition, the open field defines emotionality on a phenotypic basis. The use of animals classified as emotional on the basis of genotypic characteristics would not only minimize the regression difficulty but help shed light on some of the experimental problems brought forth by the present research attempt.

E. SUMMARY

In an investigation of the susceptibility of emotional and nonemotional rats to chronic environmental stress, 12 emotional Ss and 12 nonemotional Ss were subjected to tone-shock pairings 20 hours daily for 22 days. Twelve emotional rats and 12 nonemotional rats served as nonstress controls. The stress groups did not differ with respect to adrenal size and incidence of stomach lesions; however, emotional Ss lost significantly more body weight than did nonemotional stress Ss. This is attributable to the significant decrement of food intake of emotional rats during stress.

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DEVELOPMENT OF AN INFANT IN A CAPTIVE GIBBON GROUP*¹

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A. INTRODUCTION

One source of interest in the study of development of the gibbon is its significance for primate taxonomy. It is generally agreed, on the basis of anatomical evidence (3, 4), that the gibbon stands in evolution somewhere between the catarrhine monkeys and the anthropoid apes. The sparse comparative behavioral data on the gibbon can neither affirm nor negate this classification, although the evidence that does exist indicates that gibbons are not superior to monkeys on some commonly used laboratory tests of behavior (5, 7, 9, 13). Aside from laboratory tests, there are other aspects of behavior that might be helpful in completing the taxonomic picture. One of these is the general rate of development of an infant's independence from its mother. It is well known that higher animals are characterized by longer periods of development relative to their life span than are lower animals, and that this phenomenon applies within the primate series as well. This principle, together with the anatomical evidence just mentioned implies that the rate of a gibbon's development is somewhere between that of the catarrhine monkeys and that of the great apes.

The relationship between developmental rate and phylogeny might be related also to the mode of life of the species. The arboreal existence of the gibbon requires more complicated locomotor adjustments than does life on the ground. It may be, therefore, that (merely because of their arboreal habitat) infant gibbons stay with the mother longer than do more terrestrial forms. In the same way, since food is plentiful in the gibbon's natural environment, weaning might tend to occur earlier than expected from the general developmental rate of other behavioral functions. To learn whether variations in the development of particular behavioral functions are superimposed upon a general

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developmental rate, knowledge about the infancy of a wide sampling of primate species is desirable. Detailed studies of behavioral development in primates other than the gibbon have been made for humans (8), for chimpanzees (15), and to a lesser extent for gorillas (11, 12), rhesus monkeys (6, 10), and cebus monkeys (14); but more extensive observations are needed.

The development of gibbons has been studied before. Belle Benchley (1) has outlined some important aspects of the first three months, and Carpenter's monograph (3) includes descriptions of many of the significant behaviors. More recently, Welt and Welker (16) have reported on the postural and locomotor development of a hand-reared animal.

B. METHOD

The group consisted of an adult male and an adult female gibbon (*Hylobates lar*) and their male infant who was five weeks old at the beginning of the study. The male and female had been in the Lincoln Park Zoo for 12 and two years respectively, and both had been donated to the zoo by private families. The pair had had at least one previous baby who died in infancy. The study was continued until the mother died, when the infant was 53 weeks old.

The animals were observed in their $10\frac{1}{2}' \times 7\frac{1}{2}' \times 9'$ home cage located in the Monkey House of the Lincoln Park Zoo. The front, roof, and top half of the back wall were bars; the remainder of the cage was made of tile and concrete. There was a horizontal ledge across the back of the cage, $4\frac{1}{2}'$ from the floor, and a small perch was attached to the front bars at a height of $4\frac{1}{2}'$. A tree trunk was also placed vertically at the center of the cage from floor to ceiling, and this trunk had branches extending to the front bars and both ledges. An alley led from the back ledge to an outdoor cage. The door from the inside cage to the alley was sometimes open and sometimes closed, but the door to the outdoors was always closed. The adult male was shut in the alley continuously during the first three and one-half months of the infant's life, but since the door was made of bars the male could contact the mother and infant during this time.

The group was observed for a half-hour session between 8:00 a.m. and 9:30 a.m. twice a week. Each session consisted of 30 15-second observation intervals, one minute apart, during which the animals were watched intensively. The quantitative data to be presented were based on observations during these 15-second intervals. In addition, significant behaviors occurring between the intervals are also described.

C. RESULTS AND DISCUSSION

Table 1 shows the age at which a number of representative behaviors were first seen and gives a general idea of the rate of development.

A more quantitative impression of the rate of development of independence may be secured from a consideration of the total amount of any kind of contact between the mother and infant over the first year. The per cent of intervals during which there was any kind of contact is given for half-month periods in Figure 1. At the beginning of the second month, the infant was in contact with the mother during all of the intervals; then there was a decrease until the fifth month, with the level remaining at about 70 per cent thereafter. Variations in the level of contacts were partly conditioned by what occurred during the observations. The mother always retrieved the infant if something unusual occurred, if the male played too vigorously with the infant, or if the infant called or reached for her. The tendency of the mother to retrieve the infant was especially notable when the cage was cleaned. This tendency declined with the infant's age, but in the 11th and 12th months, the infant was still with its mother during 93 per cent of the intervals in which the cage was cleaned.

Figure 1 also depicts another general measure of independence. A record was taken of the number of intervals any traveling occurred (traveling being defined roughly as independent movement over at least six inches of space). The first instances of travel were seen at the beginning of the third month, a month after the infant first began to leave the mother and hang on the bars of the cage. The level of travel rose rapidly after this until it reached a level of roughly 50 per cent and fluctuated around that level thereafter.

1. *Mother Contacts*

The general measures of the development of contact and of travel subsume under them changes in the modes of these activities. In the second month, the infant was carried in two main positions. The first of these was a vertical posture in which the infant sat straddling the mother's hips in a ventro-ventral position. This position was used when the infant suckled or when he was fairly wide awake. When the infant was in repose, it was carried with its legs still straddling the mother's hips, but with its body between her abdomen and one thigh. *In both postures, the mother supported the infant with flexed legs rather than with her hands* (see Figure 2).

Figure 3 shows the prevalence of the two foregoing modes of mother-infant contacts over the year. The vertical posture is maintained at about the same

TABLE 1
MONTH IN WHICH VARIOUS BEHAVIORS WERE FIRST OBSERVED

Month	Behaviors			
	Posture	Travel	Responses to self and environment	Social behavior
2	Carried in female's lap or hanging from her legs or back; sits with support; sits on substrate with back against female's thigh; hangs on cage bars in contact with female.		Grasps and mouths self; grasps cage bars; looks at female and male.	Suckling; touched female's face; female grooms infant.
3	Hangs on bars independent of female; erect with support.	Climbs on cage bars and female.	Scratches self.	Female bites infant lightly; reaches for female; female transfers infant from herself to cage bars; male grasps infant.
4	Sits independently.	Quadrupedal locomotion on horizontal surface.	Grasps; mouths; bites and eats food; licks water from hand; picks up bits of detritus. "Emotional shake."	Pulls female's hair; bites male; fearful of male; male tries to hold infant on him; wrestles with male; infant tries to take food from adults.
5	Hangs by one arm from roof with pendular swing.	Hops.		Male and female pull infant when he hangs; infant takes food from adults.
6		Takes hands off floor momentarily while walking or running quadrupedally; climbs across roof to female.		Grooms female.

TABLE 1 (*continued*)

Month	Posture	Behaviors		
		Travel	Responses to self and environment	Social behavior
7		Brachiates to go to female.		
8		Brachiate independent of female.		
9		Bipedal walk to female; stands erect without support.	"Running game."	Hangs in front of female and suckles; tries to open female's mouth.
10		Jumps across open space.		
11				
12				

level throughout the year, but lying in the abdomen-thigh flexure decreases (presumably as the growing weight of the infant makes it inconvenient for the mother to carry it for prolonged periods and as the infant begins to be able to move around by itself).

During this stage of development the mother groomed the infant, especially in the perineal region. She also would shift its position on her by pushing it from the vertical to thigh-abdomen posture and sometimes would prevent it from suckling in this way. In addition, when she was seated on a ledge she sometimes lifted it by one of its arms and set it down next to her. On one occasion, she was seen to hold it away from her while it urinated; an action that Benchley (1) did not observe.

Suckling is not being reported in detail because in the early months it was difficult to observe; however, suckling did continue to occur throughout the year, although in the last three months instances of nursing were mainly limited to short occurrences when the infant contacted the mother momentarily during bouts of play.

The infant began leaving the mother in the second month, and at that time another group of more tenuous contacts began to occur (see Figure 4). The infant would hang or sit between the mother's legs while she moved around or hung from the ceiling. At times the infant would hang on by itself; at other times the mother would support it between her legs. Although these

postures between the legs represented more tenuous contacts than those represented in Figure 3, the infant was still supported completely by the mother. In addition to being between the legs, the infant at this time was also seen occasionally to hang from the mother's foot or back and to straddle

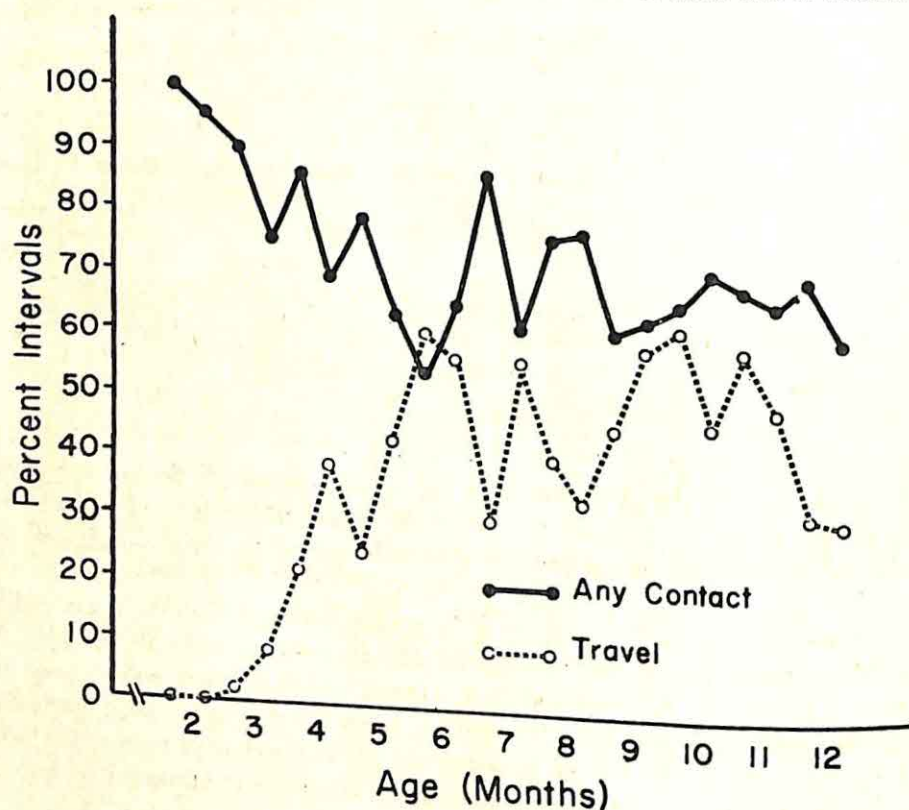


FIGURE 1
THE DEVELOPMENT OF INDEPENDENCE AS REFLECTED IN TRAVEL AND
CONTACT WITH THE MOTHER

her hip. On a number of occasions he rode "piggy back" for short periods, but this never was a prominent posture and occurred mainly in the second month.

As the infant became still more independent, postures began to appear in which the mother did not support all of the infant's weight. The most prominent of these was one in which the infant sat on the floor between the mother's legs with its back against the inside of one of her thighs. This position was taken when the mother was on a horizontal surface and was often associated



FIGURE 2
THE INFANT IN THE THIGH-ABDOMEN POSITION. NOTE THE FLEXION
OF THE MOTHER'S LEGS

with suckling. It was recorded once in the second month and once in the third month, but appeared prominently beginning at the end of the fourth month (Figure 4).

The final main category of contacts with the mother consisted of tenuous nonspecific contacts. In this category are included early instances in which

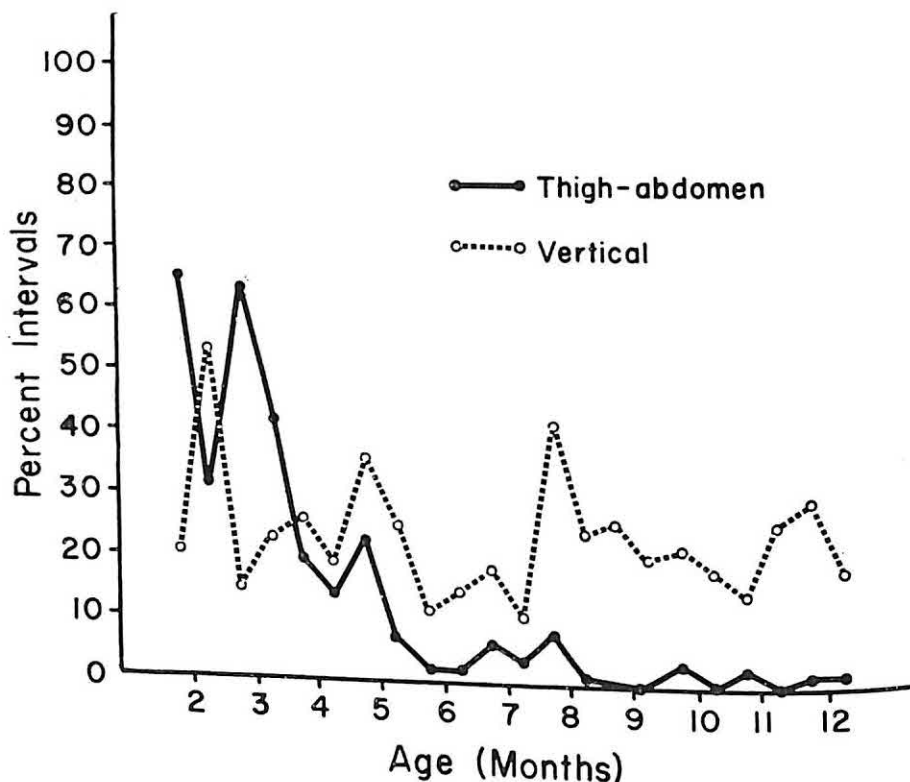


FIGURE 3
CONTACTS IN WHICH THE MOTHER SUPPORTED THE WEIGHT OF THE INFANT

the mother groomed the infant or gave it momentary support. Later, when the infant was more independent, it would brush against her, sit in contact with her but in no usual posture, climb on her, sit on her head and shoulders, etc. The incidence of these nonspecific contacts tended to fluctuate over the year (Figure 4). Earlier, they represented instances in which the mother would remove the infant from her in order perhaps to groom it. Later, the infant initiated most of these contacts.

Other modes of contact with the mother also occurred, but they were rare. If the female lay on her back, the infant sometimes sat next to her leaning over her chest and suckling. In later months, the infant sometimes suckled while it sat facing the mother or when both animals were hanging from the roof by their arms.

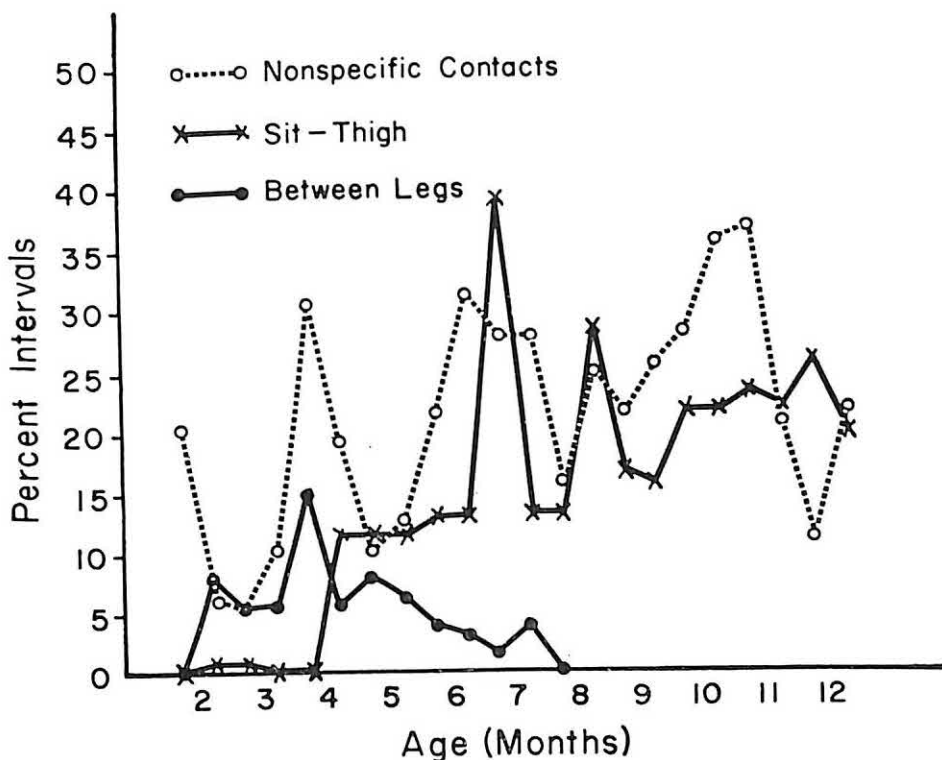


FIGURE 4
CONTACTS IN WHICH THE MOTHER DID NOT SUPPORT ALL OF THE WEIGHT OF THE INFANT

2. Travel

Prior to the beginning of the third month, the infant was with its mother most of the time. Occasionally, he would be seen hanging from the vertical bars of the cage. At the beginning of the third month, the infant began to climb on the bars himself; and, during the next month and a half, he spent more time climbing (see Figure 5). The mother stayed very close to him at this time, sometimes keeping her body under him. Always near him, she

promptly retrieved him if he vocalized or reached for her or if something unusual occurred. It was at this time that the only clear case of tuition by the mother was observed. She would aid the infant in the transition from her to the cage bars by the following maneuver: while the infant held on to her, she

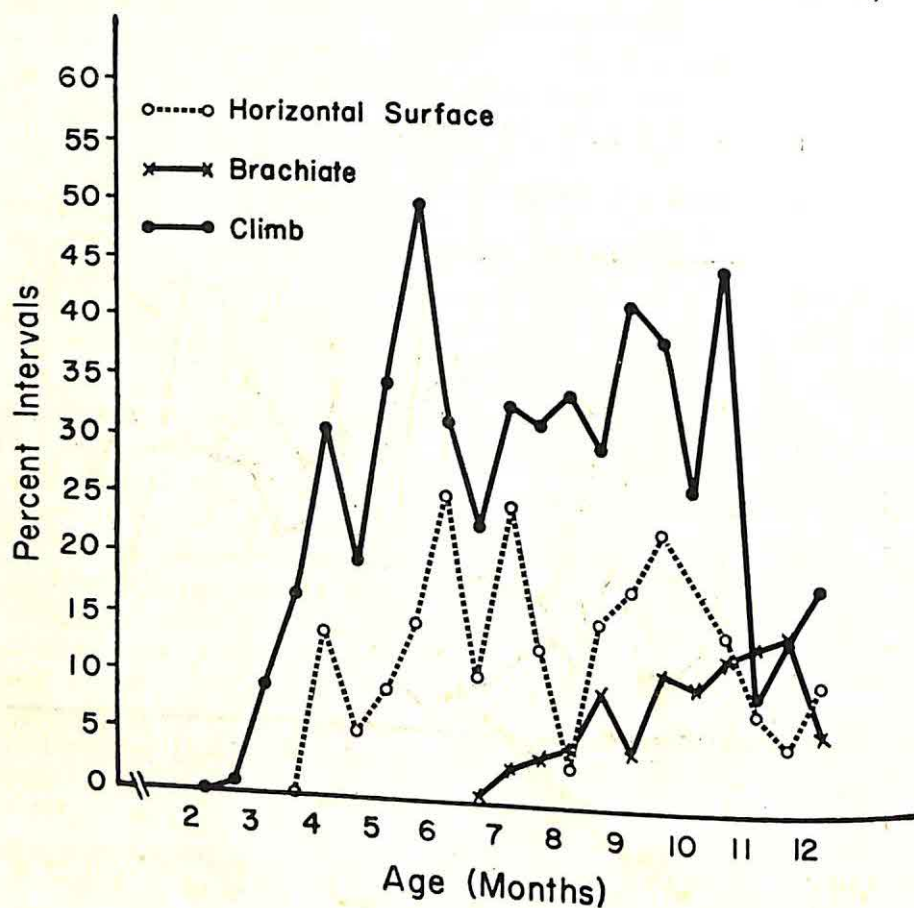


FIGURE 5
DEVELOPMENT OF THREE TYPES OF TRAVEL

would grasp his left wrist in her left hand and his left foot in her left foot and pull his left limbs to the side. The result was that the infant faced in the same direction as the mother, holding to her with its right arm and leg and with its left limbs held by the mother. With the infant in this position the mother went to the cage bars and transferred him from her body to the bars. This action occurred repeatedly during the third and fourth months.

Also during this time, it was noted that the infant hung from the bars or

roof with one hand and at the same time held on to the mother with the other.

While the infant was gaining facility in transferring from the mother to the vertical bars and in climbing on the bars, locomotion on a horizontal surface began to develop (Figure 5). At the end of the fourth month, locomotion on the floor or back ledge began. The infant (who was sitting well by himself at this time) moved from a seated position to a quadrupedal stance by shifting his weight forward onto his hands. He would then travel on all fours. This walking then developed into a stage in which the infant ran with most of its weight on its hind feet, sliding its hands on the floor in front of him. In the fifth month, he put less weight on his hands and finally lifted them off the floor occasionally while he ran. An erect stance with support was seen first in the middle of the third month, but it was not until the beginning of the ninth month that genuine bipedal walking occurred. At this time also he made a lot of hopping movements and rushed across the floor.

During the development of quadrupedal and bipedal walking the infant was becoming facile in climbing on the vertical bars of the cage and was hanging by one arm and upside down by two legs. His activities were almost completely limited to the walls, the floor and the ledges; and up to the seventh month he had not moved over open space, although he would occasionally hang from the roof very close to the vertical bars. In the end of the fifth month, he began to swing in a pendular fashion by one arm, grasping his legs with the other arm, and biting his legs. This was done very vigorously and was one of a number of kinds of play in which he engaged. Hanging and swinging probably were activities preceding the development of brachiation, but brachiation was not observed until the middle of the sixth month. Even then, it was observed only once and that was when the mother moved away from the infant rapidly and the infant (who was apparently frightened) followed her. It was not until the beginning of the seventh month that brachiation across an open space was seen prominently, and it developed during the next three months (Figure 5) until it was an easily used means of locomotion in the tenth month. Until the eighth month it was used only for following the mother.

The fact that brachiation did not become a common mode of locomotion until at least a month after its first appearance implies that the infant was hesitant to cross over an open space even though he had the capacity to do so. This may also have accounted at least partly for the fact that he did not jump from limb to limb of the tree until the tenth month.

3. *Responses to the Environment*

Achieving locomotor independence is a convenient measure of the rate of development. The ability to move around reflects the increasing complexity

of the infant's interaction with the environment as he becomes more facile in dealing with the physical and social environment. While he was still wholly dependent on the mother for transportation and food, the infant began responding to the environment. During the second month he reached out and touched the bars of the cage as the mother went past them. He grasped and mouthed his feet and he oriented toward the male, showing signs that he was afraid of him. By the middle of the third month he was seen to grasp objects and in the middle of the fourth month he mouthed food and ate. At this time also, he drank by putting his hand in the water fountain and licking water off of it. Later he often was seen to lean over the fountain and lick from it.

4. *Play and Social Behavior*

Most of the infant's activities consisted of locomotor play and interactions with the adults. Once brachiation had developed, the infant spent a good bit of time scampering over the branches of the tree, swinging under them, and running along them. During the second half of the year he spent much time in a "running game." In an erect posture and with arms above his head, he would run for a short distance and then suddenly fall prone. This action was repeated many times, with the animal stopping for a few seconds to go to the mother and suckle briefly.

Social play also occurred between all members of the group. Before describing it in detail, comment about the structure of the group is in order. During the first three months of the infant's life, the male was kept shut in the alley in back of the cage. Although he was separated from the group by bars, many of the social activities seen later were also seen at that time. The animals sometimes sat together, and the adults groomed each other, and on occasion the male grabbed at the female. After the male had been released into the large cage, it became apparent that his relationship to the mother-infant pair was a peripheral one. Ordinarily, he sat by himself apparently ignoring the mother and the infant; however, at times his interaction with them was vigorous, and these exchanges were some of the most interesting behaviors seen.

While still caged by himself, the male sometimes reached through the cage bars and grasped the infant firmly around the neck or torso. Later, when he had been released into the main cage, he often would grasp the infant in this way or pull down strongly on his legs. This was usually done while the infant hung from the bars, and the male would pull down on the infant's body so that a good bit of tension was placed on the infant's arms. Pulling down on the infant while he hung from the bars was also occasionally done by the

female. Since this activity was initially seen in the period when the infant was beginning to hang from the cage bars and to brachiate, it was first interpreted as a means of strengthening the infant's facility in hanging; however, it was often associated with mock biting and occurred at times when the adults were wrestling with each other so that it probably was a form of play fighting. The infant was definitely afraid of the male around this time. Whenever the female left the infant, the male would quickly approach the infant and grasp his body. Often the infant would vocalize, and the female immediately retrieved him or distracted the male by grooming or wrestling so that he attended to her rather than to the baby.

At this time, also, the male showed some maternal behavior. In addition to grasping the infant's body, he sometimes tried to hold it on his abdomen and cuddle it or carry it there. The infant apparently did not like this because the male had to hold him tightly in order to carry him any distance, and the infant usually escaped immediately.

These play acts were initiated almost completely by the male in the early months. However, beginning mainly in the fifth month the infant bit the male and tried to wrestle with him, and for the next few months these exchanges looked more like mutual play fighting. Finally, in the last three months of the year the male rarely initiated play with the infant, but merely endured the rather frequent occurrences in which the infant pounced suddenly on him from behind and above. Occasionally, the male responded briefly by wrestling with the infant or grabbing at him, but ordinarily these attacks were ignored.

Berkson and Schusterman (2) recently reported a series of studies of reciprocal food sharing of gibbons. Gibbons who are in a compatible group often may be seen to take food from one another. This represents something other than a dominance relationship because food passes in both directions between pairs of animals. Food sharing is far more frequent in preadolescent animals than it is in adults, and we suggested that it might represent a way for a young arboreal animal who is not agile to obtain food conveniently.

The gibbon infant first attempted to take food from the mother in the fourth month at about the time he first was seen to eat solid foods. It was also the case, however, that the mother would not ordinarily permit him to take food unless she had more than one piece herself. Further, the mother sometimes took food from the infant even though there was other food available nearby. Finally, each of the animals was seen to take food from the other at one time or another. From these observations it may be concluded that food sharing is probably not *exclusively* an adaptation permitting a young animal to get

food, although this behavior might also have that effect. Rather, food sharing in gibbons probably reflects the gibbon's rather casual attitude toward food and, when it occurs, a compatibility between group members.

D. CONCLUSIONS

These observations, together with those of other investigators, indicate that the rate of development of gibbons appears to be somewhere between that of monkeys on the one hand and that of chimpanzees and gorillas on the other. This aspect of behavior of the gibbon, therefore, is in conformity with the place in evolution assigned to it on the basis of anatomical evidence.

The possibility that the particular mode of life of the animal might affect the developmental rate of particular behavioral functions is not as easy to assess in the absence of detailed developmental data from other arboreal animals; however, it does appear that quadrupedal locomotion was not inordinately delayed nor maturation of feeding activities accelerated. It appears likely, therefore, that developmental rate is determined more by phylogenetic level than by the mode of life of the species.

This is not to say that special adaptations during development do not occur. The dependent state of infants of higher primates requires that they receive support from the mother in order to maintain contact with her. More-terrestrial mothers provide this support with their hands; while the gibbon, who must use her hands for traveling, provides this support by flexing her legs to make a lap in which the infant rides. At the time when the infant is first leaving the mother, she very carefully aids it in transferring to the vertical bars of the cage and hovers around it. These are probably adaptations to ensure that the infant will not fall from the trees. A similar effect is probably also served by the infant's resistance to crossing an open space until rather late in development when his locomotor maturation has reached a high level of facility.

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THE MOTIVATIONAL EFFECT OF VALUE SYMBOLS AND COMPETITION UPON PROBLEM-SOLVING BEHAVIOR IN CHILDREN*

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A. INTRODUCTION

It seems that at a very early age children learn to alter or adjust their behavior in order to receive maximum benefit from a situation in which reinforcement or social pressure plays a role. Some research with children has been done in the area of verbal reinforcement, such as that by McCullers and Stevenson (3); however, most experiments have concentrated on observing children in groups, and few have tested them individually in a reinforcing or competing situation (1, 2, 4).

The purpose of this experiment was to investigate the effect of value symbols and social presence upon the performance of 5-year-old children in a problem-solving situation. To create such a situation, a special game was developed. The basic objective of the game was to have the children perceive the underlying pattern in a cyclic sequence: for example, in a 2-4-6-2-4-6-etc. cyclic pattern—given that 2 is followed by 4, 4 by 6, and 6 by 2, what comes next? For this sort of game to make sense to children, it was necessary to cast the problem in a nonarithmetic framework. This was achieved through the use of an apparatus similar to that employed in the ancient carnival game of the pea under the shell. A circular array of six cups was presented to the subjects, and they were asked to guess under which cup an object (normally an ordinary plumber's washer) had been hidden. After having guessed, the child was shown the true location of the object. The object was then hidden under the cup corresponding to the next number in the sequential pattern. Again, the subject tried to guess the object's location and so on for a specified number of trials.

Two subexperiments were carried out: the first one dealing with the power of value symbols as motivators; the second concentrating on the impact of social presence. More specifically, Experiment I asked the question, "will the mere presence of a 50 cent piece as the hidden object lead to improved perfor-

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mance?" The question in Experiment II was, "what is the effect of testing the subjects in pairs rather than individually?" This latter question was further structured in terms of two distinct situations depending on whether or not the paired subjects had knowledge of one another's performance. The first situation will be called "paired response awareness"; the second, "paired presence."

B. SUBJECTS

Subjects were 37 boys and 41 girls attending a kindergarten class of a public grammar school. Their mean age was 5.6 years (ranging from 5.0 to 5.10).

C. STIMULUS MATERIALS

The apparatus consisted primarily of a wooden circular tray, six blue cups, and two small objects. The six cups lined the rim of the tray, and beside each cup was placed a number from 1 to 6. A piece of cardboard was pasted under each cup to secure its position. The objects to be hidden were a gray circular washer and a 50 cent piece.

D. PROCEDURE

Each subject was given two tests: a preliminary test and a main test. The preliminary test was identical for all subjects and served three functions: (a) acquainting the subjects with the game, (b) providing a basis for the formation of equal-skilled groups and pairs, and (c) providing a base neutral-motivation level for future comparisons.

The preliminary test, which consisted of 10 trials, was based upon a 1-3-5 sequential pattern. The subjects were scored according to the total number of correct responses. On the basis of these scores, they were divided into matched groups for the main test.

Four variants of the main test were employed in order to assess the effect of the various motivational factors being studied. A feature common to all four variations of the main test was a 10-trial test period based upon a 1-2-3-4 sequential pattern.

In Experiment I, two versions of the main test were employed differing only in the object hidden. The control group employed the same washer as in the preliminary test. For the experimental group, this washer was replaced with a 50 cent piece.

In Experiment II, three groups were formed: (a) paired response awareness, (b) paired presence, and (c) control. The main test for the control group was identical to that in Experiment I. For the paired-presence group, the only

difference consisted in playing the game with two children at a time. Each child in the pair knew only how well he himself was doing; i.e., he revealed his answer only to the experimenter. In the paired response-awareness group, the two children still guessed and reported their choices independently; however, they were made aware of each other's guesses immediately after each trial.

The general instructions used for the preliminary test were as follows:

Placed before you are six blue cups numbered from 1 to 6, and under one of these cups I shall place an object. I want you to try to figure out under which cup I have placed it. Point to the cup under which you think the object is, and if it is there, you have chosen the correct cup; if it is not, I shall pick up the correct one to show you the object. You are to turn around and hide your eyes while I place the object under one of the cups. There is a certain rule which I shall follow in hiding the object, and by paying close attention, you will be able to figure out this rule. The object which I shall hide is this round washer.

No mention was made of reward nor of any form of external reinforcement: for example, in Experiment I the children were given no indication that they might receive the coin. In Experiment II, every effort was made to avoid inducing a sense of competition.

E. RESULTS AND DISCUSSION

Two types of comparison were made. First, each group's main-test results were compared with its own record on the preliminary tests. This was done to study the degree of improved performance within each group and determine whether or not the experimental conditions of the main test yielded positive effects. Second, the main-test scores of the several groups were compared in an effort to obtain a ranking of the performance improvement among the groups.

Table 1 shows that in Experiment I (the 50 cent piece *versus* the washer) the control group did not exhibit significantly improved performance. This indicates that extraneous factors such as practice, fatigue, and the different sequences employed did not play a major role in the experiment. On the other hand, the experimental group (the coin group) did reveal an improved performance significant at the .01 level ($t = 5.09$). In the improvement-ranking analysis, the experimental group main-test scores exceeded those of the control group to an extent that was also significant at the .01 level ($t = 3.67$). The mere presence of a 50 cent piece seems to have acted as a strong motivational force for 5-year-old children.

In Experiment II, the three groups were the paired response-awareness group,

the paired-presence group, and the control group. Table 2 shows that the control group failed to exhibit improvement. This was also the case for the paired-presence group. The paired response-awareness group, however, showed improved performance, the confidence level being .01 ($t = 4.31$). In the improvement-ranking analysis, the main-test scores for all three groups were evaluated in a simple analysis of variance. F was significant at the .01 level ($F = 7.03$; $df = 2, 49$). Using the t test applied to the group means, all combinations of two groups were analyzed, but the only significant comparison obtained was between the paired response-awareness group and control group ($t = 3.08$, $p < .03$). The other ranking comparisons did not lead to statistical significance.

TABLE 1
MEAN NUMBER OF CORRECT RESPONSES ON THE PRELIMINARY TEST (PT) AND MAIN TEST (MT) IN EXPERIMENT I FOR THE EXPERIMENTAL AND CONTROL GROUPS*

Groups	Mean scores		t	p -value
	PT	MT		
E ($n = 13$)	1.85	6.23	5.09	<.01
C ($n = 13$)	1.85	2.38	1.18	>.05

* Hidden object for experimental S was the 50 cent piece; for control S, the washer.

TABLE 2
MEAN NUMBER OF CORRECT RESPONSES ON THE PRELIMINARY TEST (PT) AND MAIN TEST (MT) IN EXPERIMENT II FOR THE EXPERIMENTAL GROUPS (E_1 AND E_2)* AND CONTROL (C) GROUP

Groups	Mean scores		t	p -value
	PT	MT		
E_1 ($n = 14$)	2.14	5.07	4.31	<.01
E_2 ($n = 18$)	2.39	3.78	1.78	>.05
C ($n = 20$)	2.50	3.00	.57	>.05

* E_1 is paired response-awareness group, E_2 is paired-presence group, and C is the group of subjects tested individually.

The results support the hypothesis that pairing the subjects with mutual response awareness produces a heightened level of motivation; however, the results do not support the claim that pairing without response awareness produces performance superior to that achieved when the children are tested individually. Thus, response-awareness appears to be the crucial factor.

Two important points should be stressed concerning the value symbol in Experiment I. First, at no time were the subjects given reason to believe that they would receive the 50 cent piece as a reward, nor did they at any time give

any indication of expecting this or any other reward. This strengthens the hypothesis that the *mere* presence of this value symbol is the source of the increased motivation.

The second point concerns the manner in which the subjects perceived the 50 cent piece. Only one of the 13 subjects in the experimental group was able to identify the coin correctly. Most referred to it as a dime, a few as a penny or a quarter. It would be interesting to see whether or not performance improvement is correlated with the subject's value estimate.

In Experiment II, question remains as to the nature of the superior motivating factor present in the response-awareness group. Since the children were not told of one another's guesses until each had secretly reported his choice to the experimenter, a desire to work with or help the classmate could *not* have played a role; consequently, the author is led to believe that a sense of competition was the primary source of the improved performance. The improvement for the paired response-awareness group, therefore, represents the positive effects that competition has upon performance. On the other hand, scrutiny of the detailed scores raises the possibility that in some cases the competition situation may produce a *negative* effect on performance. This effect is evidenced by many pairs in which the high scorer did very, very well; while the low scorer did very poorly. Although the data were insufficient for statistical analysis, the presence of some form of "competitive discouragement" may have been present.

The sequence-board game developed for this study proved to have many advantages. It is relatively free of any dependence upon the subject's verbal or arithmetic background, and it requires no prior experience and little training; moreover, by varying the difficulty of the sequence, one can use it for testing children of virtually all ages. Most important, it is a task that children seemed to enjoy. For these reasons, the sequence-board game appears well suited to a wide range of experiments concerned with abstract problem solving in children.

F. SUMMARY

This experiment tested the ability of 78 five-year-old children to perceive the sequential pattern employed in changing the trial-to-trial location of a hidden object in a circle of six cups. Experiment I (in which the subjects were tested individually, and the nature of the object was varied from a plumber's washer to a 50 cent piece), was concerned with the power of value symbols as motivators. A positive effect was obtained. Experiment II, in which the subjects were tested in pairs, concentrated on the impact of social

presence upon the subject's problem-solving behavior. The results showed that the effect of social presence is found to vary according to its relation to a crucial variable: knowledge of the opponent's performance.

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PERCEPTION OF QUANTITY*

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BETSY ESTES AND ANN COMBS

A. INTRODUCTION

This is an investigation of the development in children of perception of quantity using two-dimensional figures and three-dimensional figures.

Mussen (7, p. 359) states: "Although the growth of number concepts has received much study, there have been few experiments with children on the perception of quantity or numerosity."

Long and Welch (6) investigated the development of the concepts of "larger," "sameness," and the two concepts combined in children 30 to 83 months of age. In a number-discrimination test, *S* was presented with one box of 10 marbles and a second box with marbles varying from one to 10. The task of *S* was to choose the box with the larger number of marbles. In a number-matching test, two marbles were placed in front of *S*, who was then presented with 10 to 15 marbles and asked to match the number in front of him. This number was increased until *S* failed to match correctly. In a third test for group matching, four groups of marbles were placed in a six-inch radius: two groups of two marbles, and two groups of three. *S* was asked to identify the larger groups, then the smaller. One marble was added to each group until *S* failed. The results indicate that each test measured a separate trait; and that performance improves in a negatively accelerated curve with age, with a higher correlation between performance and chronological age than between performance and mental age.

Long and Welch concluded that discrimination of number is developed by 6 or 7 years of age. In a study of the development of mathematical concepts, Piaget (8) found several clearly defined developmental stages. Wohlwill (9, p. 345) states: "The development of a concept has its origin in an essentially discriminative function of abstraction, proceeding thence by a process of the gradual elaboration of mediating structures to an eventual state in which the concept exists as a purely representational symbolic entity."

Wohlwill presents the foregoing phases as (*a*) the initial phase, in which number is responded to on a perceptual basis; (*b*) the intermediary phase,

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in which individual numbers are responded to in conceptual terms; and (c) the final phase, in which the relationship among individual numbers is conceptualized.

Estes (4) and Elkind (3) showed that success in comparing quantity increases with age. Elkind also found that this result is affected by the type of material used, liquids being significantly harder to compare than sticks or beads. Feigenbaum (5) found a strong positive relationship between age and success in understanding the number concept and a second positive relationship between the number of beads used and the difficulty of the task. Dodwell (2), however, found that at any age level there is considerable variation among the types of responses, and that intelligence or *IQ* is the factor that determines attainment of numerical concepts. Dawson (1) studied apprehension by grouping but found that "first graders could not apprehend more than four or five elements as a group. With more, they tended to count."

B. PURPOSE

In the present study, the author investigated the development of the concept of "more"; that is, the perception of quantity. Hypotheses to be tested are as follows:

1. The number of correct responses increases with age.
2. Three-dimensional stimuli elicit more correct responses than do two-dimensional stimuli.
3. There are no sex differences.
4. There are no group differences caused by order of presentation.
5. The number of incorrect responses varies according to the size of the stimuli and the numerical differences between the two stimuli.

C. METHOD

The subjects (*Ss*) were 40 children in attendance at the University of Kentucky Nursery School and the Bluegrass Cooperative Nursery, Lexington, Kentucky. There were two groups at each of the 3-year-old and 4-year-old age levels, 10 *Ss* in each group. Each subgroup contained five girls and five boys. The age range for the 3-year-olds was 3 years and 2 months to 4 years and 3 months (mean = 3:9). The age range of the four-year-olds was 4 years and 4 months to 5 years and 2 months (mean = 4:9). All *Ss* were members of the upper-middle socioeconomic level and superior intellectual level.

Two types of stimuli were used: red-ball stickers pasted on 5" × 7" white index cards formed the two-dimensional stimuli; blue marbles on small paper

plates were the three-dimensional stimuli. The numbers of stickers and marbles were presented in combinations of two numbers from one to 13, with the difference in number between the two stimuli varied from one to three. With the exception of the first two combinations, the order of presentation and the position of the correct stimulus were randomly determined. The first two combinations were 1 and 4, and 2 and 5; and were used to make certain that *S* understood the procedure.

Each *S* was given the following instruction: "We are going to play a game. Each time I show you something, you must tell me which is *more*. Do it quickly and when you are right, I will say 'right.' Do you understand? All right, here is the first one. Now tell me which has *more*."

Each *S* was presented with 30 trials of each type of stimulus. *S* had to respond within two seconds, so that he would not have time to count. *S*s who received the cards first and marbles second are called Group I; *S*s who received marbles first and cards second are called Group II.

After the first 15 trials, *E* said: "You did that so well that I want to give you a piece of candy. . . . Now tell me which has *more*."

The child was given four M & Ms (candies) during the course of the experiment, one after the first 15 trials of each stimulus and one at the end of the trials for each stimulus.

D. RESULTS

Table 1 shows that age is a significant variable with both orders of presentation and with both types of stimuli.

Although there is no statistically significant difference between types of stimuli, the three-dimensional stimuli (marbles) elicit more correct responses than do the two-dimensional stimuli (cards). No differences according to

TABLE 1
COMPARISON OF THE PERFORMANCE OF 3-YEAR-OLD
AND 4-YEAR-OLD CHILDREN

Stimulus	3		4		<i>t</i> *
	Mean	<i>SD</i>	Mean	<i>SD</i>	
<i>Group I</i>					
Cards	20.00	5.14	26.30	2.87	3.21
Marbles	21.80	4.57	27.10	2.42	3.16
<i>Group II</i>					
Cards	19.90	4.48	25.90	1.37	3.85
Marbles	18.60	4.62	24.80	4.29	2.95

* All *t*'s significant beyond the .01 level.

sex or order of presentation were found. Analysis of variance shows no significant differences in incorrect responses when the errors are divided into three groups according to the numerical differences between stimuli: i.e., large, medium, and small differences; however, lower numbers with larger differences (e.g., one and four) result in fewer incorrect responses than do larger numbers with smaller differences (e.g., 10 and 11).

E. DISCUSSION AND CONCLUSION

The results support the first hypothesis that perception of quantity increases in children between the 3rd and 4th years. There are consistently more correct responses to the three-dimensional stimuli than to the two-dimensional stimuli, although the differences are not statistically significant.

The data support the third hypothesis of no sex differences, although the 3-year-old girls do better than the 3-year-old boys. Order of presentation is not a significant variable. The fifth hypothesis is not conclusively substantiated, although there is a trend for the difficulty of the task to vary with the number of objects presented and the size of the difference between the two stimuli.

In conclusion, the development of the perception of quantity relative to an understanding of the concept "more" seems to occur between the ages of 3 and 4 (in both boys and girls) and is slightly affected by the type and the number of the stimuli.

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HAND PREFERENCE AND DEVELOPMENTAL STATUS OF INFANTS*¹

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A. INTRODUCTION

The investigation of lateral dominance (especially handedness) involves many aspects of behavior, all of which raise fundamental questions, such as the following. What is meant by left dominance or right dominance? What proportion of the population is right-handed? Are there age, sex, race, culture, or any other differences in relation to dominance? Why is the majority in most civilizations right-handed? Is lateral dominance inherited or environmentally conditioned? Are there any relationships between lateral dominance and other aspects of behavior, such as speech and school achievement?

The relationship between lateral dominance and other aspects of behavior long has been the subject of investigation. Giesecke (5) noted that lateral dominance concerns the whole body, not only the hands. The present investigation concerns a topic that has not been investigated: namely, the relationship between laterality³ and the developmental status of 8-month-old infants.

B. THE PROBLEM

The relationship between laterality and developmental status for 8-month-old infants has never been investigated, possibly because many shifts in hand preference have been reported before the age of 12 months. Observations to date (4) indicate that infants develop hand preference at different ages. The author in the present investigation wished to determine whether or not those

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² The study was carried out while the author was a member of the staff at Columbia-Presbyterian Medical Center, Child Development Program, New York City.

³ The terms laterality, handedness, and preference are used in the literature interchangeably. In this thesis these terms are also used interchangeably to signify the consistent use of one hand (as defined by the procedures).

who use one hand consistently more often than the other at 8 months differ from those who do not, with respect to developmental status. There is a possibility that some infants acquire efficient modes of behavior (such as the consistent use of one hand) earlier than others, and, therefore, are more advanced developmentally; thus, while Gesell in his studies was concerned with the differences in the development of handedness between the various developmental age levels, the author of the present study was concerned with such differences within one age level: namely, those of 8-month-old infants.

In view of the large number of studies implicating genetic mechanisms in the establishment of hand preference, the data were also analyzed to determine the relationship between the hand preferences of infants and those of their mothers.

C. HYPOTHESES

In view of the assumption that hand preference is one index of behavioral efficiency, the following hypotheses were tested:

1. There is a positive relationship between hand preference and the degree of general development of infants; infants who are above average in mental or motor development manifest a greater degree of preference for one hand than those who are average or below average.
2. There is a positive relationship between the hand preference of mothers and that of their offspring.

D. THE METHOD

1. *Subjects*

Ss are infants and their mothers selected (for another study) by the Child Development Program at Columbia-Presbyterian Medical Center, New York City. The infants are the offspring of a systematically sampled population of pregnant mothers who came to the Medical Center clinics for obstetrical services. Every sixth mother who came to the clinics for obstetrical services participated in the study. The sample consists of 100 babies (46 males, 54 females) and their mothers who came consecutively to the psychological unit of the Child Development Program for the 8-month-old psychological examination. Forty-four of the babies were white, 35 were Negro, and 21 were Puerto Rican. The age range of the infants was $7\frac{1}{2}$ to $8\frac{1}{2}$ months. Babies who appeared unable to give the tester a satisfactory performance because of ill health were scheduled to be tested at a subsequent time.

2. Tests and Apparatus

a. *The Bayley Mental-Development and Motor-Development Scales.*

These scales are revisions of those published by Bayley in 1933 and 1935. The new and revised scales (1) have been specially adapted for the Child Development Program, a project of the National Institute of Neurological Diseases and Blindness (NINDB). Because no published data on the reliability and validity of the new scales are available, Dr. Bayley has kindly furnished the author with the following statement:⁴

On the Mental Scales, correlations (by Flanagan's method) of the items at the 6-to-9-months level with the total score range from .11 to .91. On the Motor Scales, correlations of the items with total score (for the same age) range from .35 to .91. Considering the low reliabilities usually obtained for individual items, the present reported reliabilities appear to be satisfactory. The reliability on the total Mental Scale for 123 infants at 8 months (by the Kuder-Richardson Formula 20) is .89; for the Motor Scale, .90.

A Diagnostic Summary resulted directly from the passing or the failing of items on the Mental and Motor scales. An infant was rated "normal" on the Mental Scales if he passed the majority of items in the range of 7 to 10 months. "Advanced" on these scales meant the passing of most items in the range of 11 to 14 months; while any infant was considered "suspect" if he failed the majority of items in the range of 5 to 7 months, and "abnormal" if he failed on items below 5 months. On the Fine Motor Scales, infants who passed items in the 9-to-12-months range were rated "advanced"; those who passed the majority of items in the 7-to-8-months range were rated "normal"; those who failed two or more items in the 5 to 6-months level were considered "suspect"; and those who failed any item below 5 months were rated "abnormal." On the Gross Motor Scales, Ss who passed items in the 7-to-9-months range were rated "normal"; those who passed the majority of the items in the 10-to-12-months range were rated "advanced"; those who failed two or more items in the 5-to-6-months range were considered "suspect"; and those who failed any item below 5 months were rated "abnormal."

b. *Questionnaire on hand preference.* The items in this questionnaire have been used by other investigators [see Weinstein and Sersen (7)] and have been found to be satisfactory for determining hand preference for an adult.

The author found it possible to gather reliable data on parent hand prefer-

⁴ The author wishes to thank Dr. Nancy Bayley for her helpful suggestions and clarification of her scales (1) and for her permission to use them in this study.

ence only from the mothers. The fathers did not accompany the babies to the clinic, and it was not feasible to ask wives about husbands' handedness because some of the babies were born out of wedlock; therefore, some of the mothers did not know the fathers' hand preference or were reluctant to answer the question. The questionnaire includes 12 items. A mother was classified as having a hand preference if she used the same hand to perform at least seven of the 12 activities listed and included in these activities "writing" and "eating with a spoon." Mothers who used both hands for the majority of the 12 items were classified as "ambidextrous."

3. Procedures

The items from the Mental and Motor scales were given to all infants (without any systematic order, consideration being given to the pace set by each baby's needs at the moment of examination). The test for hand preferences of the infants was administered at the same time. A cube, a bell, and a ring were each presented four times in the center of S's vision, and S's responses were noted on a special form. Grasping the cube, the bell, and the ring a total of nine times with the same hand was considered as indicating preference for that hand. After testing, the questionnaire on hand preference was given to the mother. In order to assess the baby's developmental status, the diagnostic summary was completed by the examiner and scored according to a criteria set in a manual which accompanies the Bayley Scales.

E. RESULTS

No significant relationships were found between sex and hand preference; ethnic background and hand preference; and between sex, ethnic background, and developmental status.

1. *The Relationship Between Hand Preference and Developmental Status*

Table 1 gives the frequencies of hand preference or lack of preference in relation to developmental status. Fifty-eight per cent of the sample showed a definite preference for one hand or the other, and 42 per cent showed no preference. Of the 100 Ss, 62.0 per cent were rated normal; 26.0 per cent, advanced; and 12.0 per cent, suspect. Of the 26 advanced babies, 24 (or 92.3 per cent) showed preference for a hand, while only 28 of 62 normals (or 45.2 per cent) showed a preference. In the suspect category, 50.0 per cent showed preference; 50.0 per cent, no preference. A chi square of 15.70 ($p < .001$) supports the hypothesis that a greater proportion of the babies

TABLE 1
THE RELATIONSHIP BETWEEN HAND PREFERENCES OF BABIES
AND DEVELOPMENTAL STATUS*

Developmental status	Hand preference		Total
	Has preference	Has no preference	
Advanced	24	2	26
Normal	28	34	62
Suspect	6	6	12
Total	58	42	100

* $\chi^2 = 15.70$, $df = 2$, $p < .001$.

rated "advanced" in one of the mental areas or motor areas on the Diagnostic Summary shows a hand preference.

2. *The Relationship Between Specific Hand Preference and Developmental Status*

Having found a significant relationship between development and hand preference in the advanced category, it seemed important to analyze the data to determine whether or not developmental status is related to specific hand preference. Table 2 gives the data for those babies who showed preferences.

TABLE 2
THE RELATIONSHIP BETWEEN SPECIFIC HAND PREFERENCE
AND DEVELOPMENTAL STATUS*

Developmental status	Hand preference			χ^2	df
	Left	Right	Total		
Advanced	7	17	24	4.16**	1
Normal	5	23	28	11.57***	1
Suspect	3	3	6	0.00	1
Total	15	43	58	13.86***	1

* $\chi^2 = 2.97$, $df = 2$, ns.

** $p < .05$.

*** $p < .001$.

A chi-square test shows no significant relationship between these two categories; however, Table 2 points to the fact that in the "normal" and "advanced" categories the majority of the babies significantly prefer the right hand more than the left. No differences of left-hand or right-hand preference were found in the "suspect" category. Table 2 also provides evidence that of the total number of infants who showed a preference—disregarding specific developmental status—a significantly greater number showed a preference for the right hand. These results might lend themselves to the interpretation

that the right hand becomes preferred (in the majority of cases) fairly early in the development of the individual.

The data for the advanced category were analyzed to determine whether specific advanced developmental status (such as mental status, fine-motor status, gross-motor status, or any combination) is related to specific hand preference. Table 3 presents the data and the chi square, 3.04, which is not significant.

3. *The Relationship Between Hand Preference of Infants and That of Mothers*

Of the 94 mothers who answered the questionnaire on handedness, 91 definitely preferred one hand to the other; three were classified as ambidextrous. Of those preferring one hand to the other, 84 (or 89.4 per cent) were dextrals, and seven (or 6.4 per cent) were sinistrals. These data, shown in Table 4, follow closely hand preferences in the general population. In order to determine the relationship between hand preferences of babies and those of their mothers, *t* tests were computed for each of the following comparisons: (a) between sinistral mothers and sinistral babies; (b) between dextral mothers

TABLE 3
THE RELATIONSHIP BETWEEN SPECIFIC HAND PREFERENCE AND SPECIFIC
DEVELOPMENTAL STATUS IN THE ADVANCED CATEGORY*

Specific developmental status	Specific hand preference			Total
	Left hand	Right hand	No preference	
Mental	1	5		6
Gross motor	2	4	0	6
Fine motor	1	3	2	6
Mental and gross motor	1	3	0	4
Mental and fine motor	0	2	0	2
Fine and gross motor	2	0	0	2
Total	7	17	2	26

* $\chi^2 = 3.04$, ns.

TABLE 4
INCIDENCE OF HAND PREFERENCE OF INFANTS AND MOTHERS

Handedness classification	Mothers (N = 94)	Infants (N = 94)	df	t
Dextral				
Sinistral	89.36%	42.55%	186	6.96*
Ambidextrous (or no preference)	6.38%	17.03%	186	1.42
Total	4.26%	40.42%	186	6.20*
	100.00%	100.00%		

* $p < .001$.

and dextral babies; (c) between ambidextrous mothers and babies who showed no hand preference.

The data point to certain differences in the incidence of hand preference between the babies and their mothers, and the differences will be analyzed subsequently; however, in order to test the second hypothesis relating the specific hand preferences of the infants to that of their mothers, a chi-square test and a coefficient of contingency were computed, based on the data presented in Table 5. No relationship between infants' handedness and mothers' handedness was found.

TABLE 5
THE RELATIONSHIP BETWEEN MOTHERS' HAND PREFERENCE AND
INFANTS' HAND PREFERENCE*

Infants' hand preference	Mothers' hand preference			Total
	Right	Left	No preference	
Right	36	3	1	40
Left	16	0	0	16
No preference	32	4	2	38
Total	84	7	3	94

* $\chi^2 = 3.08$, $df = 4$, ns. $C = .03$, ns.

F. DISCUSSION

1. *Hand Preference*

The results obtained in this investigation support the thesis that developmental status of infants is related to the development of hand preference. Early establishment of hand preference, as defined by our procedures, appears to go along with advanced developmental status. The significantly higher incidence of advanced babies who preferred to use one hand than of average or below-average babies confirms the hypothesis. Thus, one might say an infant of advanced developmental status is most likely to manifest a tendency toward consistency in the choice of its parts. Such a tendency may be considered as the most efficient way of dealing with the environment in terms of grasping objects in the surroundings; therefore, the infant who manifests a response tendency (using one hand only for its activities) that is more efficient than another (using two hands simultaneously or inconsistently one hand and then the other) shows better adjustment than otherwise to its environment. This is corroborated by Bayley's data indicating an item-total-score correlation (at 8 months) of .59 for the motor-scale item "unilateral reaching." Hildreth (6, p. 210) suggests that "achieving handedness is

essentially a learning process involving habit formation, spontaneous reaction, postural adjustment, expression of choice, and responding in social situations." The point is that we are not concerned with the question of whether or not the infant will shift his hand preference after testing because hand choice for the majority of the activities during the testing is important in itself.

While the relationship between preference for one hand and developmental status is clearly demonstrated, we are also interested in determining whether or not there is any relationship for developmental status and preference for a specific hand (e.g., the right hand). Analysis of the data shows that the majority of the infants manifest a preference for the right hand. While the incidence of right-hand preference in the present sample is different from the incidence found in the usual adult population (approximately 95 per cent of adults are right-handed), it is in the same direction. The interesting fact that emerges is that *specific* hand preference is not linked to developmental status at 8 months. One must note, however, that further analysis of the data shows a significant difference in favor of the right hand for the "normal" and "advanced" categories, but not for the "suspect." In this category, 50 per cent of the Ss were right-handed, and 50 per cent were left-handed. It is difficult to account for the 50-50 split in the "suspect" category. Because of the small number of Ss in this category, it is not possible to offer clear conclusions.

2. *Handedness of Infants and Mothers*

The mothers' hand preferences are similar to those obtained from the general population (95 per cent of the population and 90 per cent of the mothers are right-handed). The data on the 8-month-old infants, however, show only about 43 per cent preferring the right hand; thus, the difference between mothers and infants is rather large. This finding, therefore, does not confirm the second hypothesis. The fact that most infants who, at the time of examination, manifested a preference for a left hand and have right-handed mothers would eventually become right-handed only poses the question that has so often been asked by other investigators: is hand preference genetically determined or influenced by training? While the present data cannot settle this question, they offer the suggestion that some training is important in the determination of hand preference because so many infants demonstrate a left-hand preference at this early age and only later shift their preference. Falek's conclusion (3) that the hand preference of an individual is an outcome of both his genetic endowment and his training at an early age in his home lends further support to the foregoing suggestion.

Brown (2, p. 173), in a study of the way 3-year-old children use their hands differentially in terms of ego syntonicity and nonegosyntonicity, suggested that the "longitudinal description of hand usage for an individual child would provide an excellent tool for research in genetic and dynamic personality description." The present study points in the same direction: namely, that a longitudinal study of the relationship between the developmental status of a child and the time of establishment of the various aspects of lateral preference might prove to be a fruitful approach to understanding growth and development.

Wilson and Dolan (8) studied the relationship between handedness and ability in sixth-grade children. They found that dextrals were slightly above the sinistrals in intelligence and achievement, and that sinistral girls were slightly superior to sinistral boys in every respect. There remains little doubt that further confirmation of the first hypothesis that there is a relationship between developmental status of infants and the consistent use of one hand might lead to the possibility of special educational programs that would be established for the purpose of negating the disadvantageous effects of left-handedness and lag in the establishment of lateral dominance. In any case, the present study points to an additional area of investigation that might clarify further the relationships between the developmental aspects of human behavior (such as hand preference) and education.

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STATE OF FOOD DEPRIVATION AS A FACTOR IN RADIATION MORTALITY OF RATS*¹

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A. PROBLEM

Previous research by McDowell *et al.* (1) concerned with diurnal variations in radiation sensitivity noted that rats fed just before exposure to radiation were more susceptible to radiation effects than were rats deprived of food for the 24 hours prior to radiation exposure.

The present research proposed to explore the effects of various feeding procedures both prior to and following radiation exposure.

B. MATERIALS AND METHODS

1. Subjects

Forty male rats, six months of age, served as Ss. These Ss were of the chocolate strain of the University of California Laboratories.

2. Procedure

All Ss were deprived of food beginning 24 hours before exposure time. Ten Ss (subsequently designated as the FF Group) were given food three hours before exposure time and *ad libitum* feeding thereafter. Ten Ss (subsequently designated as the FD Group) were given food for the three hours prior to exposure time and, then, deprived of food for 24 hours. Ten Ss (subsequently designated as the DF Group) were given free access to food after radiation exposure. The 10 remaining Ss (subsequently designated the DD Group) were not fed until 24 hours after radiation exposure. All Ss were exposed to 900 r of Co⁶⁰ given at a rate of 669 r per minute.

Days survived during the first 30 days after radiation exposure constituted the dependent variable.

C. RESULTS

Analysis of the days survived for the Ss of the four groups, using a Kruskal-Wallis one-way analysis of variance design (2), yielded a difference which was

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beyond the .01 significance level. The orthogonal comparison between the *Ss* of the FF Group and the FD Group combined against the *Ss* of the DF Group and the DD Group combined, as shown in Figure 1, also, yielded a difference which was beyond the .01 significance level. The *Ss* of the FF Group

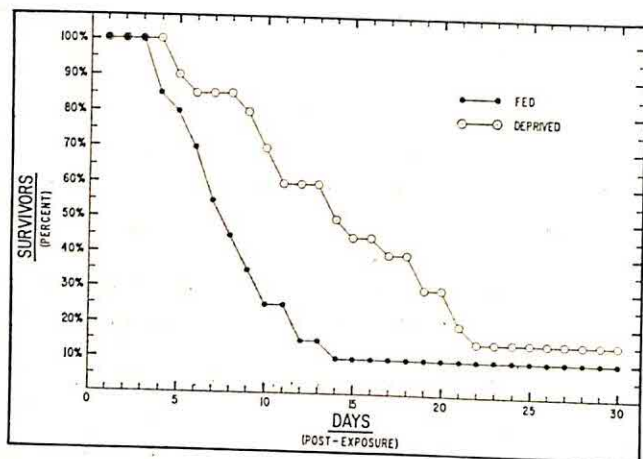


FIGURE 1
PERCENTAGES OF SURVIVORS DURING SUCCESSIVE DAYS AFTER EXPOSURE TO 900
R OF Co^{60} FOR *Ss* FED AND FOR FOOD-DEPRIVED *Ss*

failed to differ significantly from the *Ss* of FD Group, and the *Ss* of DF Group failed to differ significantly from those of the DD Group. It is, of course, obvious that the groups failed to differ significantly with respect to survival beyond 30 days.

D. DISCUSSION

The results of the present study are in direct agreement with the previous work that has shown increased radiation susceptibility in rats fed just prior to exposure. The findings also indicate that feeding schedules following radiation exposure are not related to susceptibility.

The general findings should be of considerable interest to the behavioral or biological investigator who would like to assay effects for some reasonable length of time after the fact of exposure to a lethal dose of radiation.

E. SUMMARY

Forty six-month-old male rats of the chocolate strain of the University of California Laboratories were deprived of food beginning 24 hours before exposure to 900 r of Co^{60} radiation. Three hours before exposure 10 *Ss* were

fed, and the food was left in their cages after exposure. At the same time 10 other Ss were fed, but the food was removed after exposure. Ten Ss received no food for 24 hours before and after exposure. The remaining 10 subjects received food after exposure. The four groups differed significantly with respect to survival time during the first 30 days after exposure. The Ss of the groups given no food until after exposure survived significantly longer than the Ss of the groups fed just before exposure.

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THE EFFECT OF INSTRUCTION AND PERFORMANCE SET ON COLOR-FORM PERCEPTION IN YOUNG CHILDREN*¹

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A. PROBLEM

A number of studies conducted in the past 50 years have demonstrated that children between 3 and 6 years of age, when asked to match geometric shapes that are comparable in color or in form, use color more often than do older children (1, 2, 3, 4, 6, 8, 11, 12). Several studies have been concerned with variables that influence the younger child's greater tendency than the older child to use color: for example, a high level of color response is associated with forms that are not meaningful (6, 11), solid-colored stimuli as opposed to outline-colored stimuli (5), and great complexity of the forms (5).

Kagan and Lemkin's recent study (7), which failed to find the traditional developmental differences, has been criticized because the term "cutout" was used in the instructions (4, 9); and critics assumed that the instructions produced a set that emphasized form. There is little evidence, however, to corroborate this criticism. Vokelt (12) reported that active attempts to make his young subjects shift from color to form were unsuccessful. A recent study by Aikawa (1), which manipulated a verbal set, resulted in greater variability of response with little overall group difference.

The present research is concerned with the effect of instructional sets and performance sets on the young child's color-form matching. It was expected that a performance set would produce a greater shift in response than would an instructional set.

B. EXPERIMENT I

1. *Method*

a. Subjects. The subjects came from kindergarten classes in two school systems in St. Louis County. There were 180 children (90 boys and 90 girls) ranging in age from 61 to 75 months, with a mean age of 67.5 months.

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b. Materials. Each standard figure in the color-form test was located at the top of an $11 \times 8\frac{1}{2}$ inch sheet of white paper, and two comparison figures were placed (one at the right and one at the left) below the standard. One of the comparison figures matched the standard in color but not in form, while the other matched it in form but not in color.

Four basic standard figures and four colors—red, blue, green, and yellow—were used. One of the standard figures was an equilateral triangle, the comparison figure of the same color was an isosceles triangle, and each of the other three figures was an asymmetric form with five to seven sides. The comparison figure of the same color as the standard retained the same general configuration, but was readily discriminable from the standard in shape. An example of these figures has been given elsewhere (5). The four basic figure plates were presented five times in the different colors; thus, there were 20 plates in all.

Three groups of figures were designed to induce performance sets prior to the administration of the color-form test. These figures were circles, squares, triangles, and diamonds. Each group consisted of eight plates. The performance color-set group presented a standard and two comparison figures on each plate. One of the comparison figures was the same *color* as the standard, but all three of the figures were of different shapes; consequently, the only correct response was a color match.

The performance form-set group was the same as the performance color-set group except that one comparison figure was the same *shape* as the standard. But, as the three figures were of different colors, only a form match was correct. A performance-control group was designed like the other two groups of figures except that all three figures on each plate were of different color and different form. No correct match could be made for this group.

c. Procedure. There were three instructional-set conditions and three performance-set conditions. In the instructional color-set condition, the color-form test was administered with the following question for each plate: "Which one of these *colored things* is most like this one?" The instructional form-set condition presented the color-form test with the following question: "Which one of these *cutout shapes* is most like this one?" The question used with each plate in the instructional-control condition was, "Which one of these is most like this one?" In all cases, the experimenter pointed to the two comparison figures first and then pointed to the standard as she said, "this one."

The appropriate performance-set figures were presented in each of the other three conditions prior to the presentation of the color-form test. In the performance color-set and performance form-set conditions, the instructional

control-condition instructions were used with the pretest stimuli. The performance-control group was asked, "Do either of these look like this one?" The instructional-control instructions were used with all three groups on the color-form test itself.

The subjects (*Ss*) were randomly assigned to each of the six groups, with the restriction that an equal number of boys and girls be included in each group. This gave a total of 30 *Ss*, 15 boys and 15 girls, in each group. Since it is always likely that some young children will have difficulty in understanding the nature of the task, two criteria were established for excluding *Ss*: clear side preference (defined as six or more consecutive responses to one side) and more than three errors on the performance-set pretest figures. Twenty-two *Ss* were excluded and replaced. This exclusion procedure meant that a total of 202 *Ss* were tested.

2. Results

The scores used for analysis were the total number of color responses out of a possible 20. The data summary for the six groups is presented in Table 1.

TABLE 1
NUMBER OF COLOR RESPONSES

Group	<i>N</i>	Range	Median
Instructional color set	30	0-20	3.0
Instructional form set	30	0-19	1.0
Instructional control	30	0-20	2.5
Performance color set	30	0-20	20.0
Performance form set	30	0-19	2.0
Performance control	30	0-20	2.0

A Kruskal-Wallis one-way analysis-of-variance test (10) yields a significant *H* of 40.71 ($df = 5$, $p < .001$).

The Mann-Whitney *U* test (10) was used to test for differences among the different pairs of groups. The performance color-set group was significantly different from all other groups ($p < .001$), but none of the other group comparisons was significant. It is evident that in the control group the response level to color was so low that an adequate test of the form-set conditions cannot be made.

C. EXPERIMENT II

1. Rationale and Method

The kindergarten children who served as *Ss* in the first experiment were near the upper limit of the age range that most developmental studies specify

as the age of color response. As a consequence, the level of color response was too low in the control groups to permit proper assessment of the influence of the form sets; so the second experiment was a partial replication of the first study, with younger children. It was anticipated that the control-group response to color would be greater with the younger group.

The Ss came from three nursery schools in St. Louis County. There were 120 children (60 boys and 60 girls) ranging in age from 42 to 67 months, with a mean age of 55.7 months.

Four of the original conditions were replicated. The performance-control condition was dropped because there appeared to be no difference between the control groups in the first study. The performance color-set condition was not included because the results for this group were clearly different in the kindergarten groups. Thus, the four conditions replicated were the instructional color-set condition, the instructional form-set condition, the instructional-control condition, and the performance form-set condition. The instructional color-set condition was replicated to determine whether or not preschoolers respond to these instructions in a fashion different from kindergarten Ss.

The Ss were randomly assigned to the four groups, with an equal number of boys and girls in each group. The application of the exclusion criteria earlier defined resulted in 16 Ss being replaced.

2. Results

The data are summarized in Table 2. A Kruskal-Wallis H of 6.76 ($df = 3$) was obtained ($.05 > p < .10$), and Mann-Whitney U tests were calcu-

TABLE 2
COLOR RESPONSES OF PRESCHOOL GROUPS

Group	<i>N</i>	Range	Median
Instructional color set	30	0-20	7.0
Instructional form set	30	0-20	2.5
Instructional control	30	0-20	6.0
Performance form set	30	0-19	2.5

lated for the group differences. The performance form-set group significantly differed from the instructional color-set group ($p < .05$). The differences between the instructional form-set group and the instructional-control group, the performance form-set group and the instructional-control group, and the instructional color-set group and the instructional form-set group fall between the .10 and .05 levels.

D. DISCUSSION

When both studies are considered together, the results are in the expected direction; however, the influence of the instructional color-set condition and form-set condition and the performance form-set condition are very weak. The instructional color-set group did not differ significantly from the control group in either study. The *form* sets produced results of marginal significance upon replication. It is evident that the instructional sets used had little effect on Ss' behavior; consequently, it appears that Kagan and Lemkin's failure (7) to find the usual developmental differences in color-form perception cannot be explained readily in terms of the instructions they used.

The performance color set, in contrast with the other conditions, produced a marked increase in color response. It is conceivable that the performance form-set condition might have shown a more pronounced effect if more than eight trials had been given. The results imply that young children may shift more readily to color than to form from a given base level of response. This may be surprising in the present context where the base level of the control groups favored form matching. If the shift in response for the performance form-set group in the replication study had been as marked as the shift in the performance color-set group in the first experiment, it would have been significantly different from the control group. A comparable median response level for the performance form-set group in the second experiment should have been 0.0 or 1.0.

The young Ss in the present study, in contrast with those in the earlier developmental studies of color-form perception, were not color dominant. Although these Ss responded primarily to form, the ease with which color matching was reinforced implies that the tendency to respond to color is strong.

E. SUMMARY

The study was designed to assess the effects of instructional sets and performance sets on color-form perception. Instructions stressing color, form, or neither dimension were used. Performance set was varied by presenting pre-test tasks that emphasized color, form, or neither dimension. The Ss were 180 kindergarten children assigned randomly to the six conditions. The study was partially replicated with 120 preschool children.

Instructional sets had little or no effect on color-form matching. The performance color set induced a high level of color matching, while the performance form set showed a weak tendency to induce form matching. The control levels of response favored form over color. The author concludes that young

children have a stronger tendency to match on the basis of color than may be evidenced in their base levels of response.

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